Iron and Steel ENGINEER

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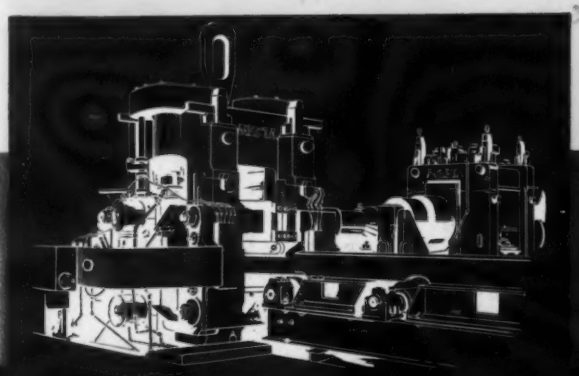
AUGUST, 1960

Mesta Universal Structural Mill Rolling Wide Flange Beams on the 44" Universal Stand and the 34" Edging Stand at Inland Steel Company, Indiana Harbor Works

WIDE FLANGE BEAM AND STRUCTURAL MILLS

Designed and Built by MESTA

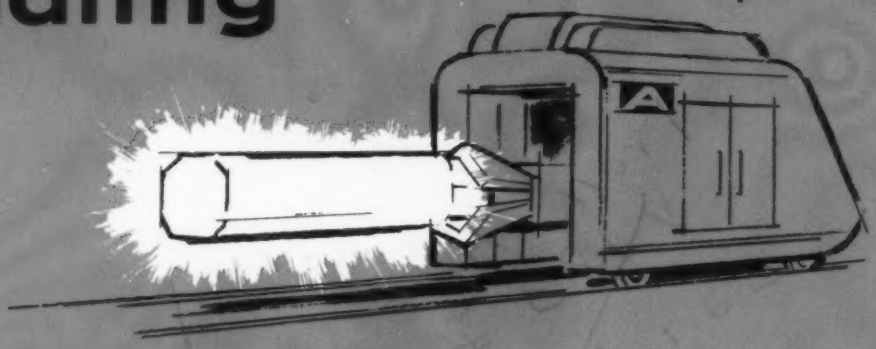


Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Push-button Billet Handling



Merely push a button and the billet is in position for any forging operation. Finger-tip electrical and hydraulic controls do the work.

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machine company

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for copper

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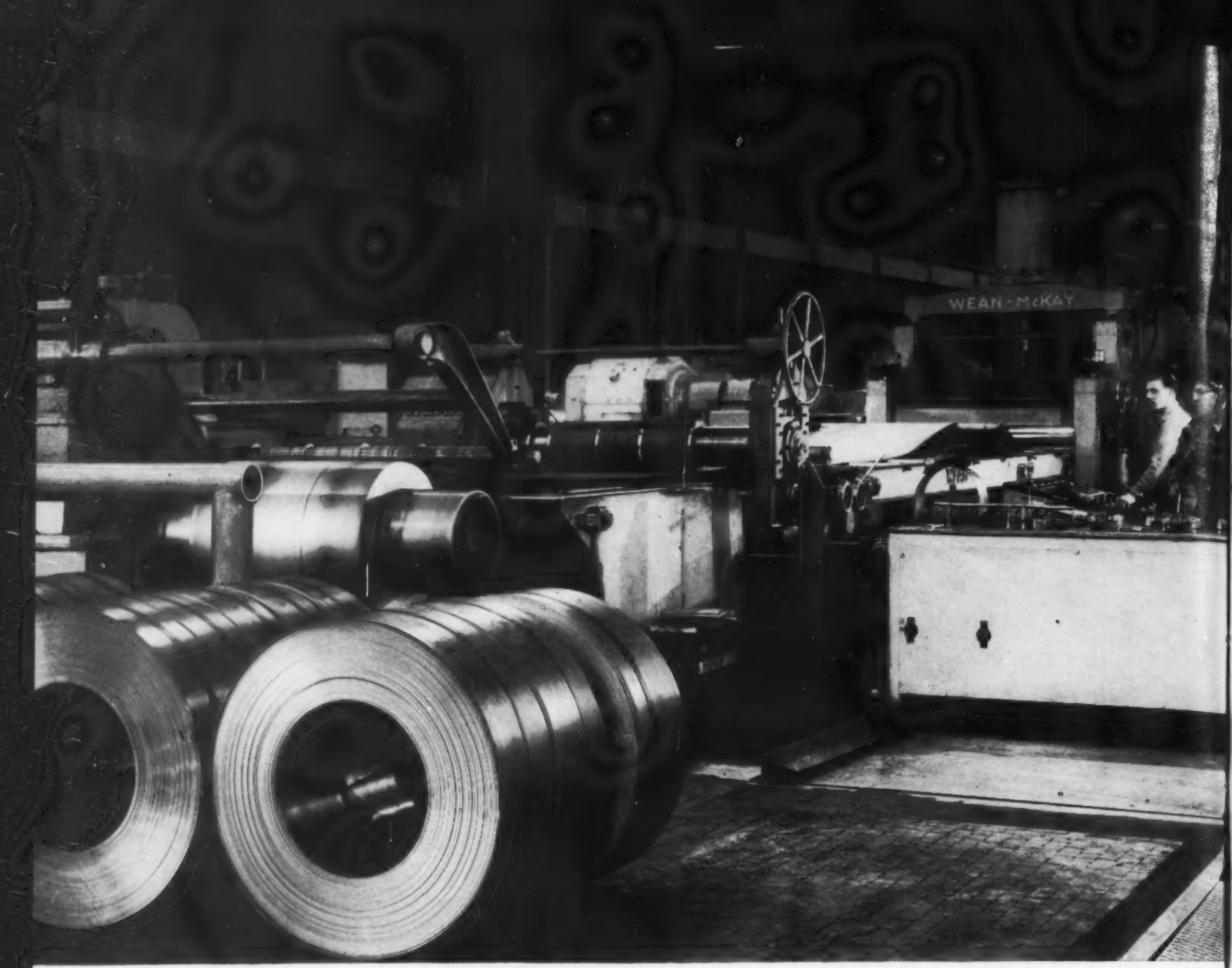

Pittsburgh Steel keeps production costs down with Wean Hot Rolled Strip Slitting Line

Pittsburgh Steel Company maintains a high production rate at its Allenport, Pennsylvania hot strip mill with this heavy duty Wean slitting line. The Wean line allows Pittsburgh Steel to follow the economical practice of rolling wide strip and then slitting it to a variety of customer-specified widths. It not only frees the hot strip mill of production runs with narrow strip, but also enables Pittsburgh to offer a wider range of strip widths.

This line can handle coils up to 60″ O.D., recoiling the slit strands on either 20″ or 24″ expanding mandrels. Strip ranging from 18″ to 60″ in width and .049″ to .188″ in thickness can be side-trimmed and slit at speeds up to 300 fpm. A processing uncoiler "works" the strip to eliminate serious cross-breaks and flattens it to permit accurate slitting.

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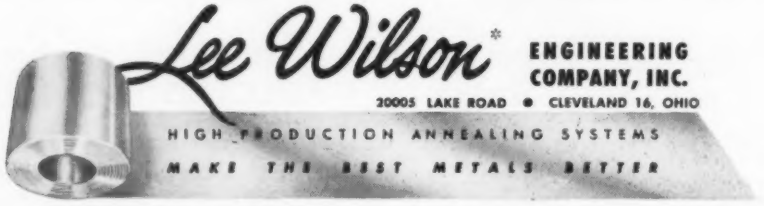

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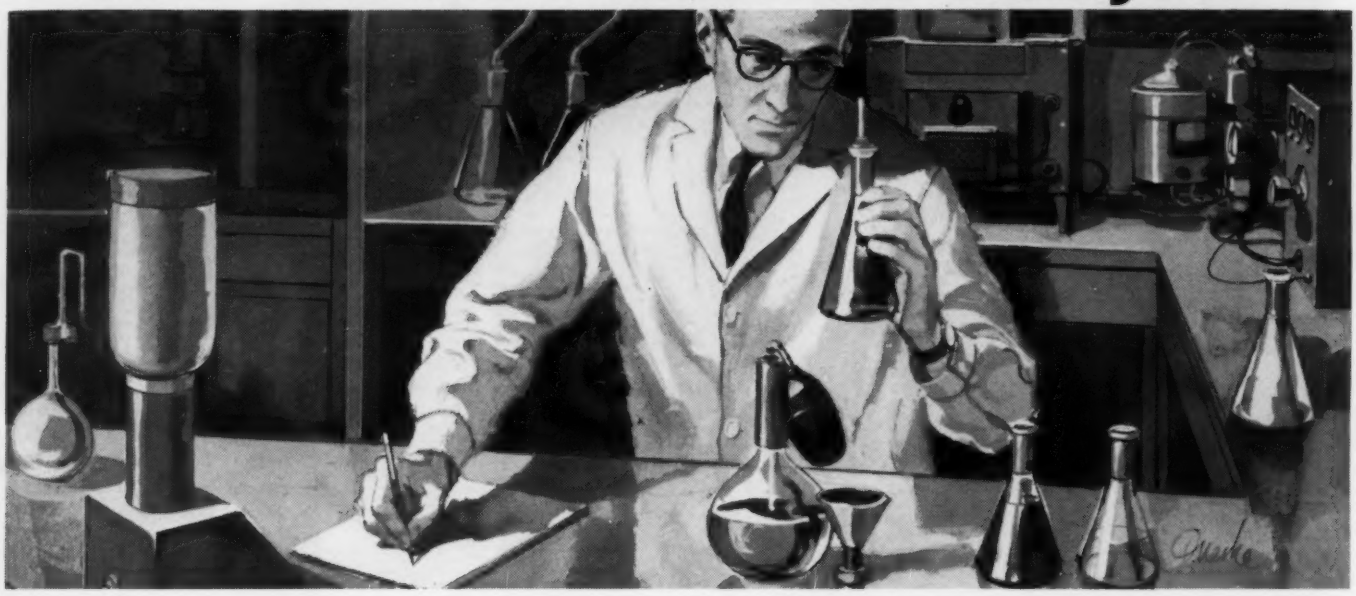
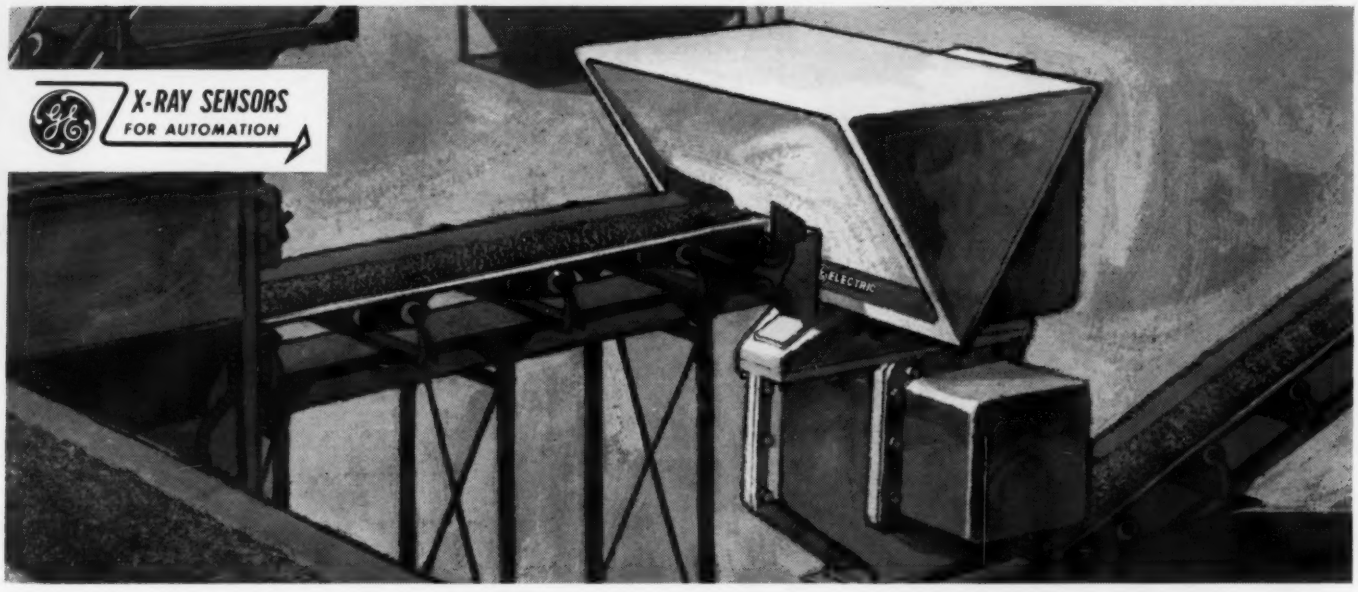


out of the lab...



onto the line!

General Electric's revolutionary X-Ray Emission Gage offers what amounts to an "on-line" *laboratory* for quality control. XEG performs continuous analysis of solids, liquids, liquid mixtures, slurries, powders, sheets, rods, wire or similar materials *during actual production.* It monitors up to 5 selected elements . . . maintains *moment-by-moment* surveillance, sensing both presence and quantity.

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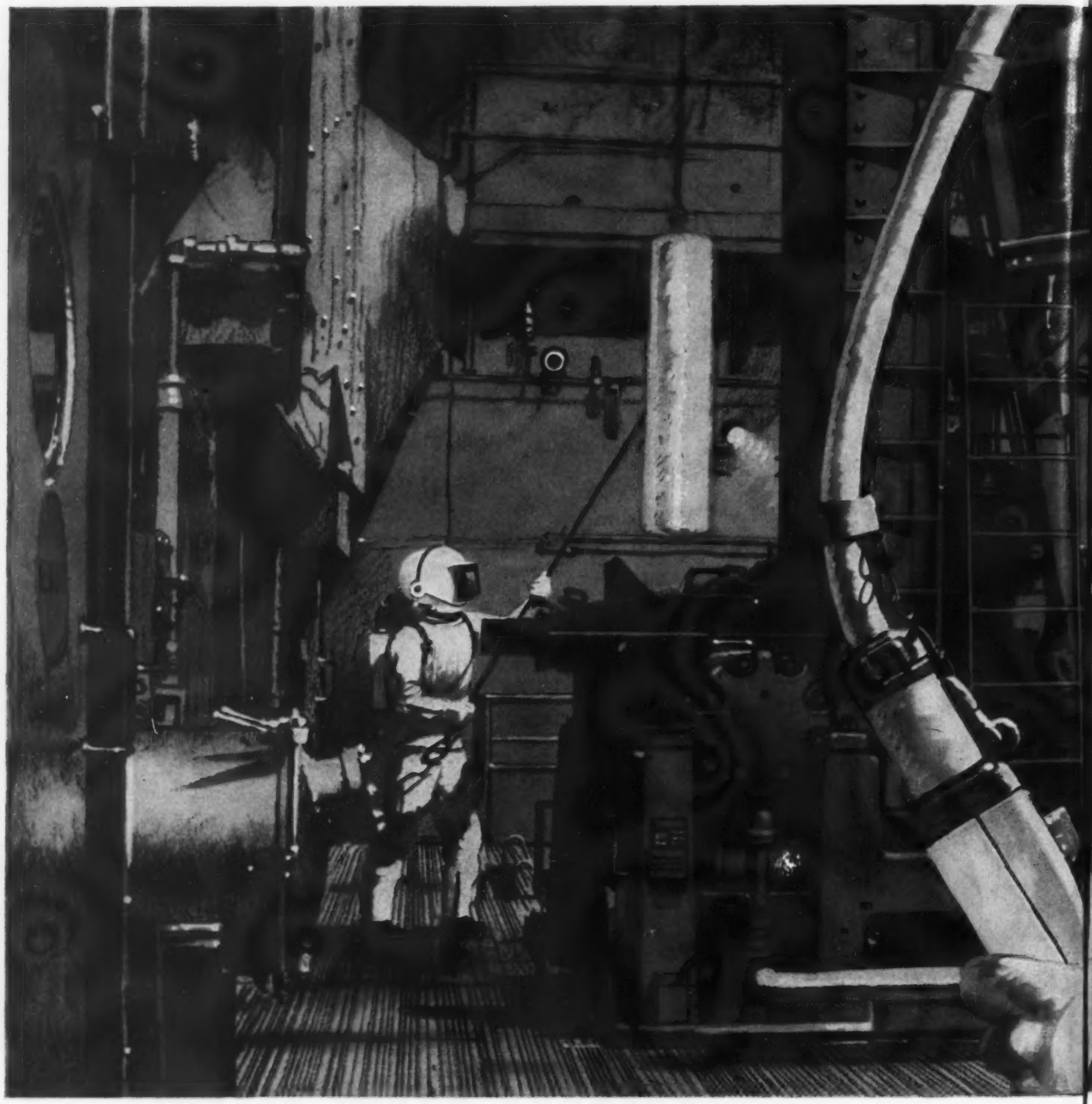

The exotic world of space a

Imagine a plant without air . . . where workers must operate in space suits . . . surrounded by an atmosphere of pure argon gas. These are the conditions at Universal-Cyclops Steel Corporation's In Fab project at Bridgeville, Pennsylvania.

This unique plant was developed because exotic space age metals such as tantalum, molybdenum, columbium, should be forged and hot processed in an oxygen-free atmosphere . . . *a world of their own.* Otherwise they may react violently or break down. Yet, because these refractory metals can retain strength far above temperatures that would destroy most materials, they are vitally needed for nose cones, re-entry vehicles, jet and rocket engines.

As a result, Universal-Cyclops—in conjunction with the Department of the Navy—built a hermetically sealed plant where rolling mill, impactor, induction furnace and

e age metals... *where Mobil is right at home!*

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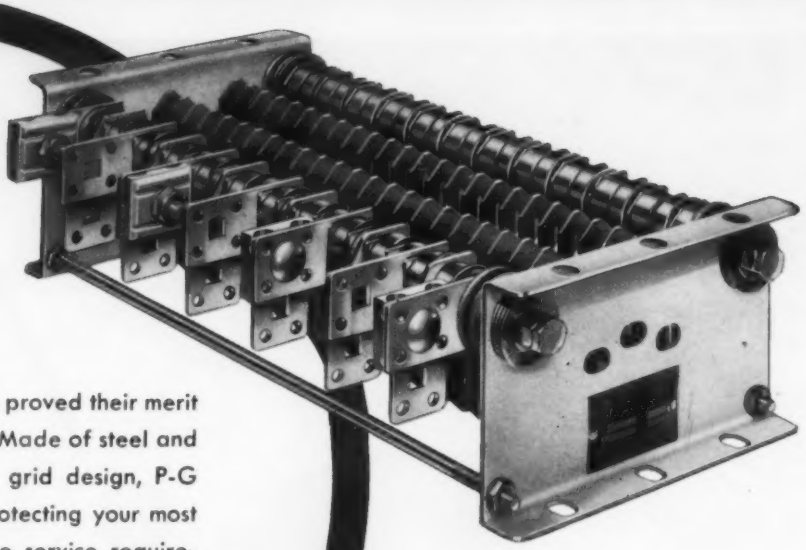

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These rugged nonbreakable units have proved their merit in all kinds of service for many years. Made of steel and mica, plus P-G unique and exclusive grid design, P-G Standard Resistors are capable of protecting your most vital electrical equipment, even where service requirements are severe. Use of correct resistance value with ample capacity minimizes resistor trouble. ***Write for BULLETIN No. 500.***

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The Nonbreakable Steel Grid Resistor

P-G

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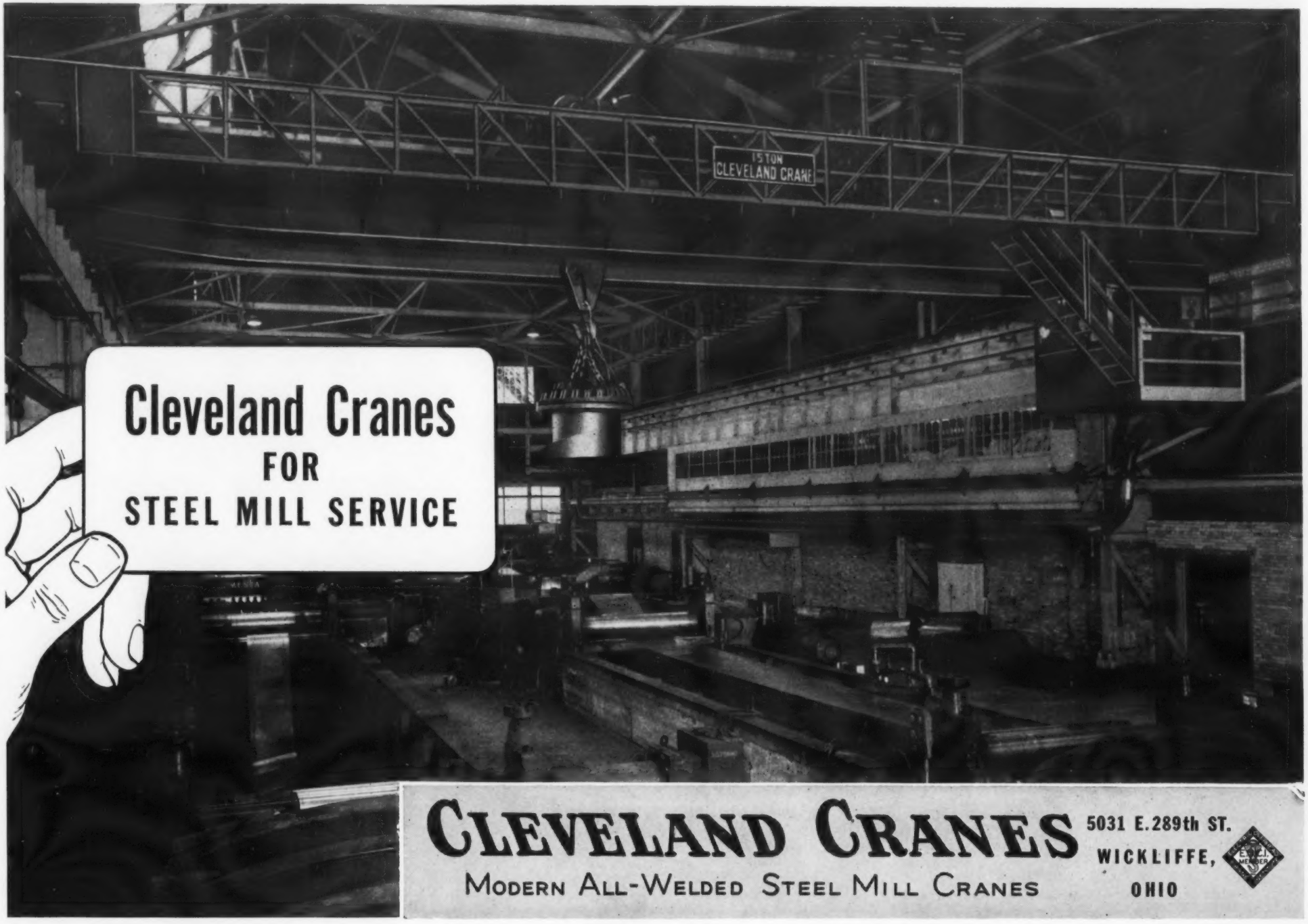
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Crops *and* Shorts

△ Your roving editor is back after visiting 32 steel plants, machinery builders, research centers and engineering socieites in England, Wales, Holland, Belgium, France, Luxembourg and Germany. It was interesting and worthwhile. We hope to tell you a little about it in the near future.

△ Incidentally, it was surprising to find a pile of large ingot molds in a British plant intended for export to a steel plant in midwestern U.S.A. The company had previously shipped molds to another midwestern plant. That's a long way to ship hunks of cast iron.

△ William A. Steele, president of Wheeling Steel Corp., says it now costs that company $19,455 to provide a job for each employee. Ten years ago, the figure was $11,109; twenty years ago $7247. These figures were determined by dividing the company's assets by the average number of employees.

△ Men may wonder what the future has in store, but women wonder what the store has at present.

△ Several speakers at the Democratic national convention made mention of "Madison Avenue" (which seems to have replaced Wall Street as a whipping boy) as a wicked Republican innovation. The term "hucksters" was also dragged in. If the speakers were referring to the use of public relations and advertising in politics and government, they will have to go back before the Eisenhower terms. Actually, that Demoractic idol, F. D. Roosevelt, first made wide use of such media—and two prominent figures of the convention were ex-ad men. In fact, one of them made about as hucksterish a presentation in offering the party platform as these old eyes have ever witnessed.

△ And just in case you're interested in predicting the outcome of the November election, you might pause to reflect that, for over 40 years, the candidate with the longest surname has won.

Another researcher says that we always elect the tallest candidate.

△ One thing sure—if we believe what each candidate says about the other, it'll be difficult to vote for either.

△ Of interest to our British members is the recent approval of the Association of Iron and Steel Engineers as an organization whose dues may be deducted for income tax purposes. This approval was granted by the Commissioners of Inland Revenue. British members who have been notified by mail, now have the same deduction privilege as that enjoyed by our members in the United States.

△ First-half steel production totaled 60,743,322 tons, third highest for any half-year on record. This represents an operating rate of 82 per cent of capacity.

△ In 1959, the can manufacturers used 4,948,955 tons of steel and produced 43,253,867,000 cans, an all-time record. This is 254 cans per capita, or 871 per family. The greatest use was for fruit, vegetables and juices, with beer in second place.

△ The season of United Funds and Community Chests is again with us. Some 2200 campaigns will be conducted this fall in the United States and Canada. Last year about $455,000,000 was contributed to such drives to support 28,000 local, state and national voluntary health and welfare agencies.

△ October 9–15 is Fire Prevention Week. The United States fire losses in 1959 totaled $1,278,808,000 in about 2,000,000 fires.

△ We have felt for a long time that our primary and preparatory school courses have been diluted with a lot of clap-trap, and sugar-coated to a point where students do not learn that work is necessary nor how to do it.

An encouraging sign is the move by a number of universities to stiffen their entrance requirements for incoming students. The changes ask for more mathematics, science and language for high school graduates. The schools also suggest that grade schools spend more time on the basic three R's.

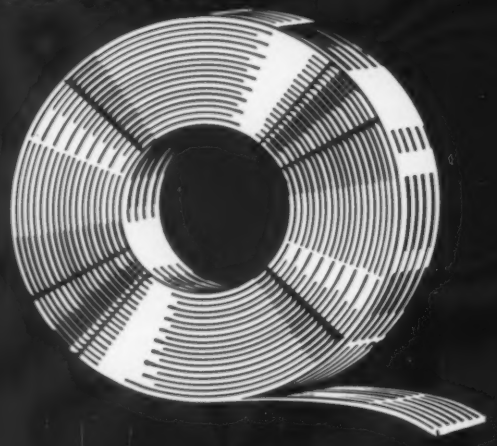
△ A recent business survey looks for the free-world nations to attain a 20 per cent rise in population and a 50 per cent gain in production over the next ten years.

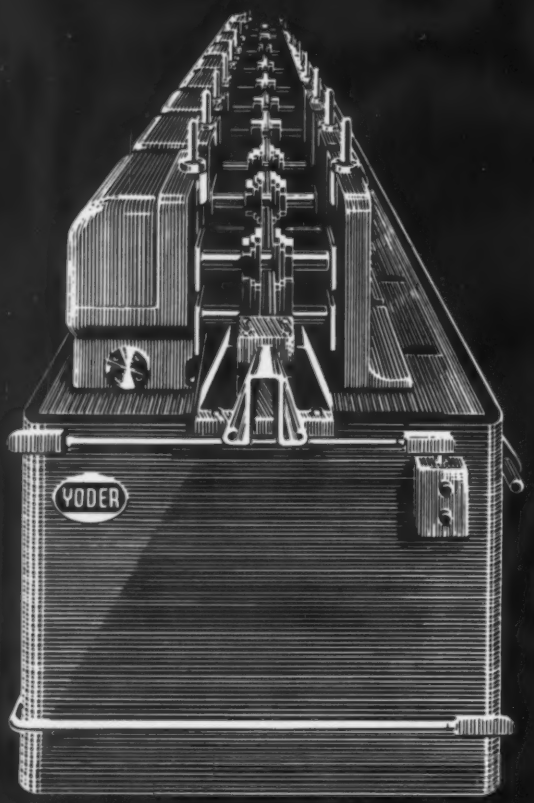
△ A correspondent tells us that, next to a beautiful girl, sleep is the most wonderful thing is the world.

△ According to Logan T. Johnston, president of Armco Steel Corporation, the steel industry of the United States spent $12,000,000,000 in new facilities since 1946. Of this amount, 46 per cent came from depreciation, 33 per cent from retained earnings, 12 per cent from loans and 9 per cent from stock sales.

In the same period, the industry averaged slightly less than 10 per cent return on its capitalization and about 6½ per cent on its sales. Dividend payments were approximately 50 per cent of total net earnings.

. . . from start





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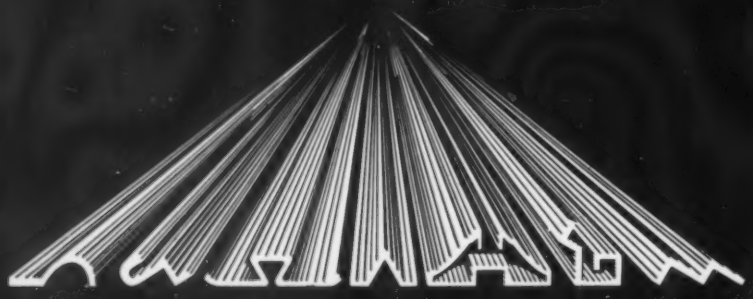

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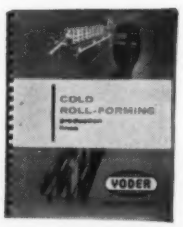

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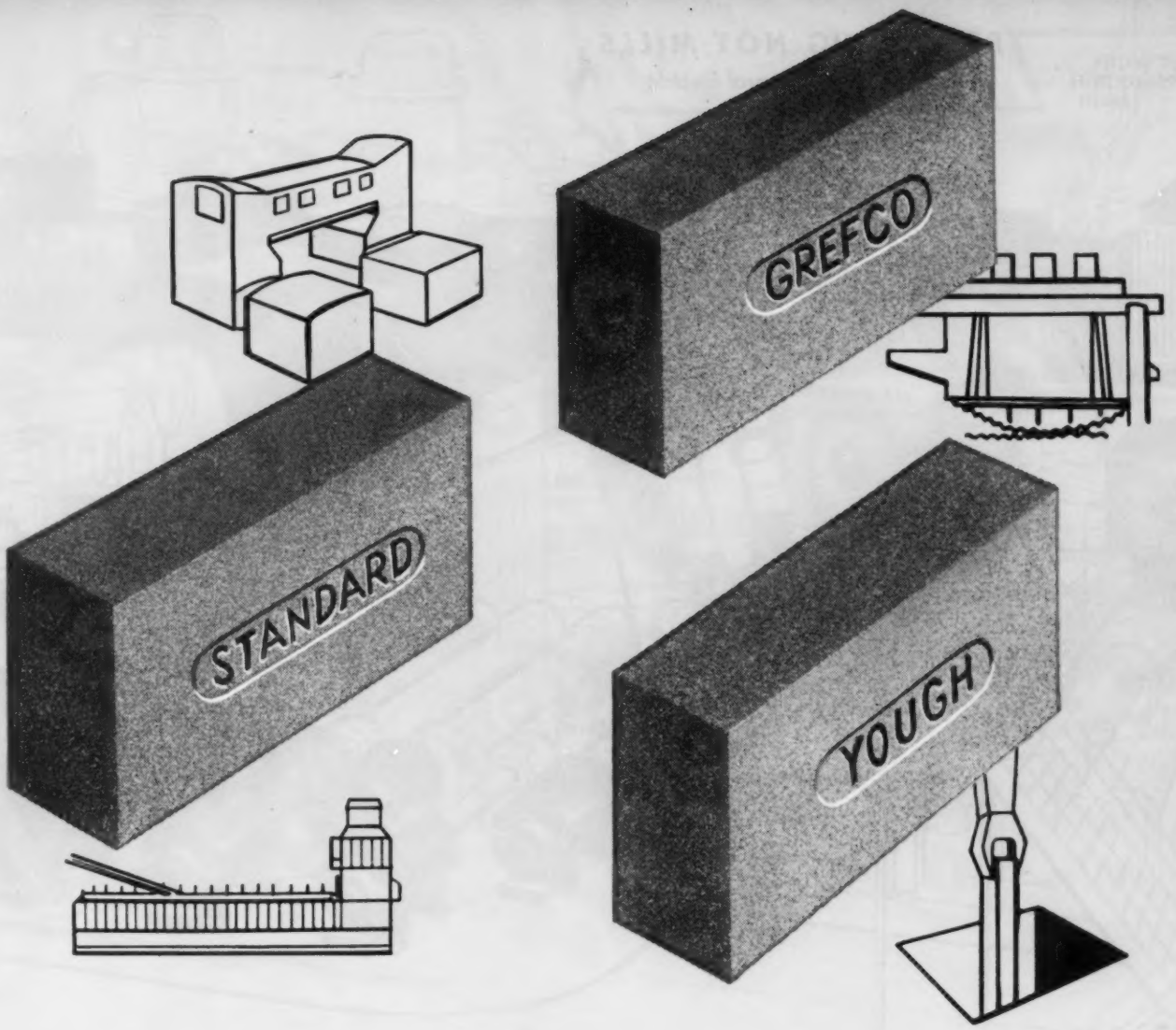

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YOUGH brand has unique properties which make it the best available brick for construction of soaking pits and other types of reheating furnaces. It is also most desirable for bee-hive coke ovens, and eyes over the arches in shaft lime kilns. With a working temperature of 2800°F, it has excellent strength and transverse rigidity under soaking heat—plus unusually high resistance to spalling. Yough brand, manufactured at Childs, Pa., is the only brick of its kind in the world.

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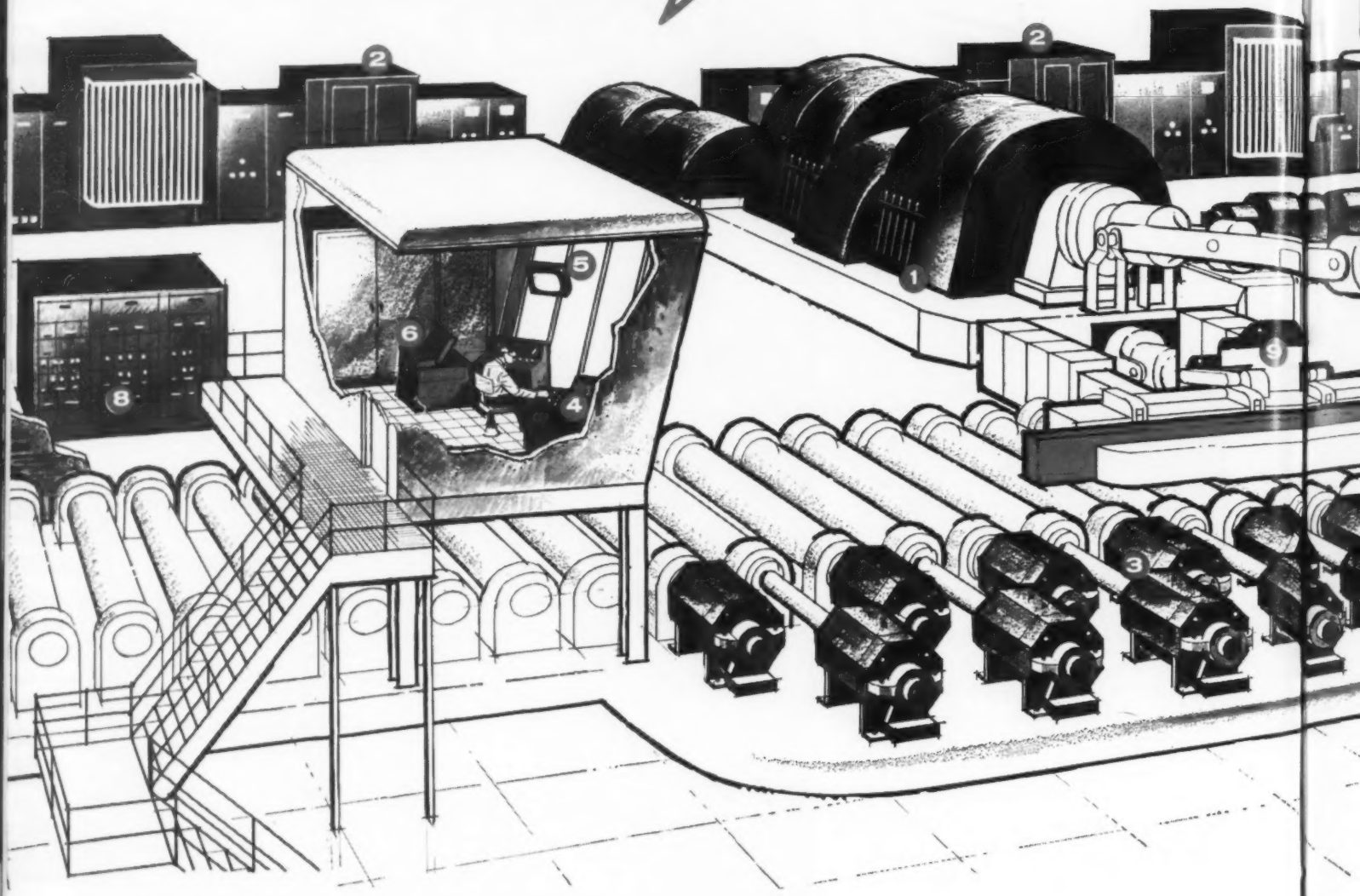
automated by General Electric



General Electric's step-by-step approach to automation is . . .

The Best Way to Meet the Competitive

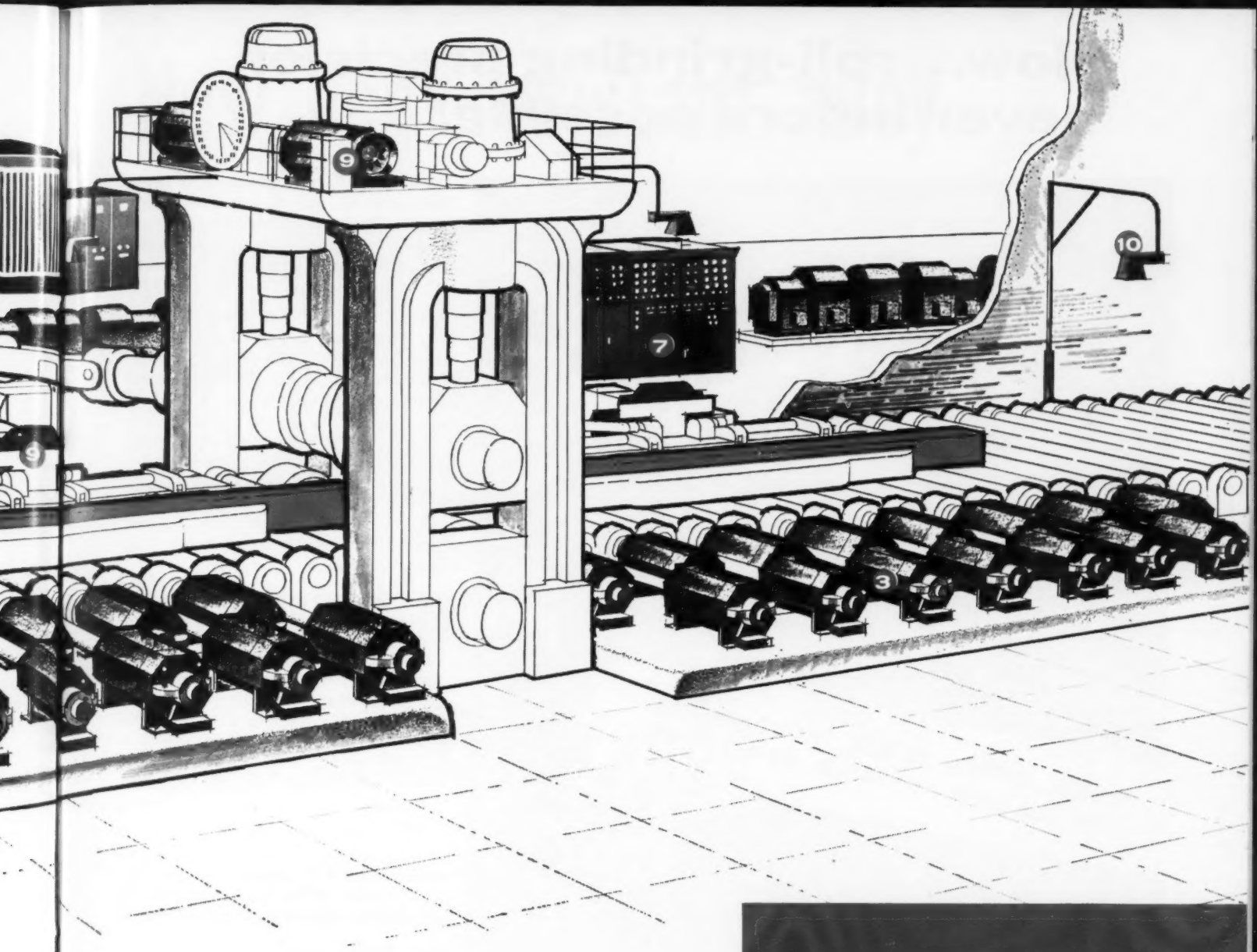
Competition in the primary metals market is on the increase today as never before. As management looks for ways to meet this challenge, their attention is turning to automation to improve production efficiency, operating costs, and product quality. But economic considerations of primary metals producers eliminate any thoughts of "overnight" automation with its hasty planning, uncertain costs, and unpredictable results.

GENERAL ELECTRIC'S PLAN is based on a series of modernization steps which combine economic soundness with predicted benefits of automation.

For example, many Reversing Hot Mills are producing automation benefits today as a result of modernization programs begun four years ago. Application of pre-programmed drafting practices is resulting in fewer passes, higher and more consistent product quality, lower scrap. Drastically reduced maintenance and equipment abuse is resulting in lowered operating costs. Automation flexibility is allowing product variations consistent with changing market requirements.

Consider the automation of *your* Reversing Hot Mill: As a first step, General Electric will help you survey your mill to determine which electrical-system components will best meet the precise demands of automation. From this survey comes a series of installation steps sequenced to keep downtime at a minimum and at the same time, make your basic system suitable for the next step—automation. As these products are installed real savings start, because General Electric system components are designed to reduce installation and maintenance costs while providing the precise response and maximum reliability demanded by automation.

THE NEXT STEP in General Electric's plan is the application of a programming system and new sensing devices, system-engineered to provide completely automatic operation of the mill and associated auxiliaries. Then it becomes possible, through the addition of an information-handling system, to observe all mill operations, compare these operations with current job specifications and, if necessary, make instant adjustments in rolling instructions which are signaled to the mill drive system after each pass.



Challenge of the 60's

Even greater savings begin in this step as maximum utilization of the mill becomes consistent with the limits of the mill, the drive system, and even the metallurgical limits of the ingot or slab. After automation of your mill has been completed, new product and system technology makes it possible to link associated production processes, such as the soaking pit, ingot buggy, and reheat furnaces, into an automated production area. Then this area can be integrated with other areas to provide completely automatic production scheduling and manufacturing throughout the entire plant. Over-all performance will be in direct accord with management decisions based on all of the many complex variables that determine profitable plant operation.

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9. MD-600 Screw-down Motors
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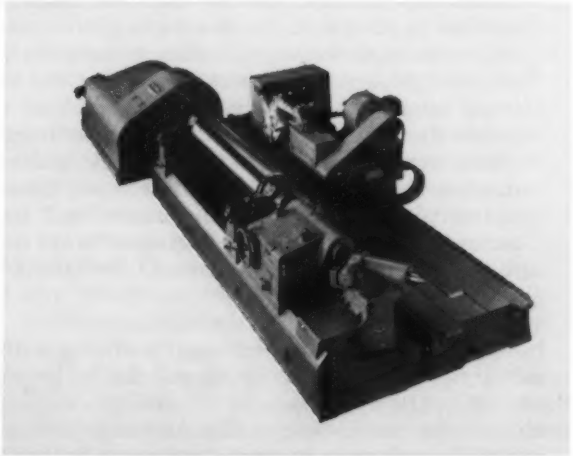

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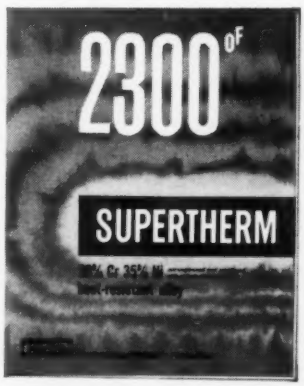

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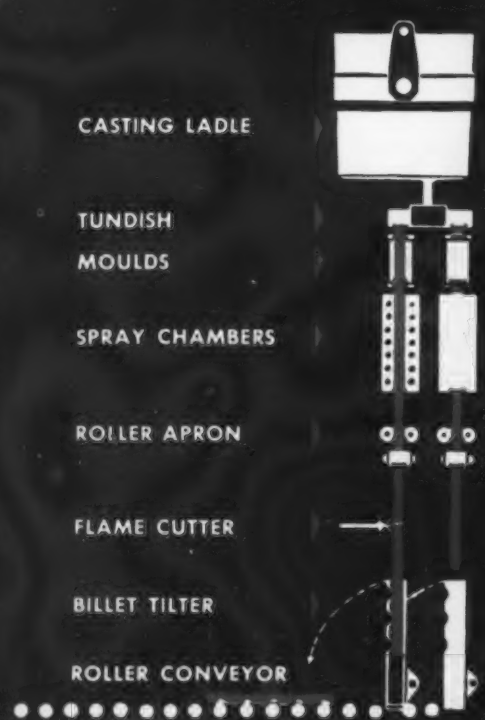

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patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents. . . patents reviewed cover period March 8, 1960 to March 29, 1960

CONTROL OF PICKLING BATHS

△ U. S. 2,927,871, issued March 8, 1960 to Edgar B. Mancke and Cloyd W. Shingledecker, assigned to Bethlehem Steel Co., provides a method and apparatus for maintaining a uniform concentration in continuous pickling baths. Automatic additions are made of concentrated acid and of dilute acid approaching the strength of the normal working bath.

In Figure 1, the steel strip 1 travels successively through tanks 2, 3, 4, 5, and 6, while pickling solution 7 flows from tank 6 successively through tanks 5, 4, 3 and 2, from whence it overflows as waste. The strip travels over carrier rolls 12 as it enters and leaves each tank. A steam line 8 is connected with each of the tanks 2 to 6 for maintenance of the proper temperature in the pickling bath. Concentrated acid is introduced into tank 6 through pipe 9, and valve 11. To this valve is connected an electrical conductivity sensing instrument 10. Dilute acid is introduced into tank 6 through pipe 13 and valve 15. To this valve is connected a specific gravity sensing instrument 14. Water spray for rinsing the pickled strip is emitted from nozzles 16.

Referring now to Figure 2, and assuming that a pickling bath 7 of desired concentration has been prepared and is in use, make-up acid may be introduced through pipe 9. This acid is concentrated sulphuric (66 deg Bé) and is added to maintain proper acid concentration in the bath. An electrical conductivity cell 10, such as a cell of the type having platinum electrodes connected to an arm of a Wheatstone bridge, is placed in the bath and connected to valve 11 through a recorder-controller instrument 25. The combination of cell 10 and the recorder-controller may be set for any desired limited range of acid concentration of the bath, so that air operated valve 11 is opened or closed depending on whether acid must be added or acid additions should be discontinued. Pipe 13 carries dilute sulphuric acid which in this case is of a concentration

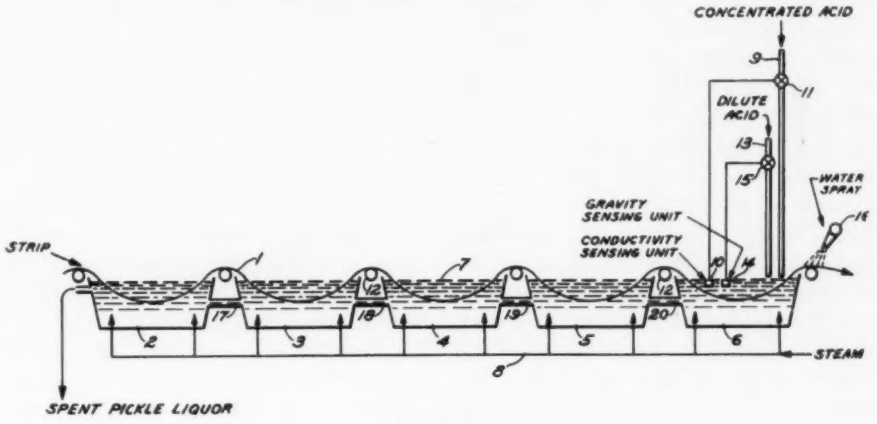
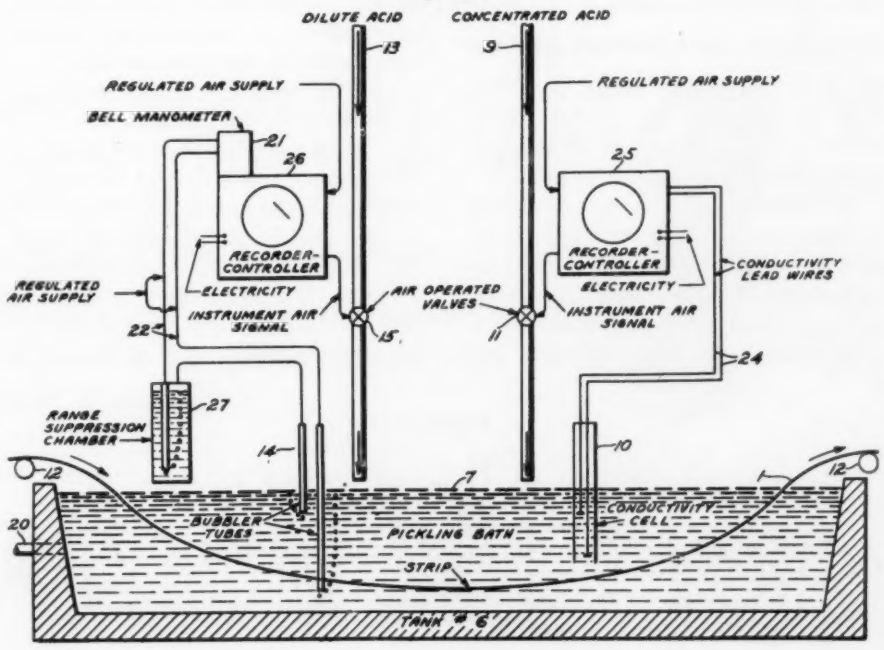


Figure 1

Figure 2



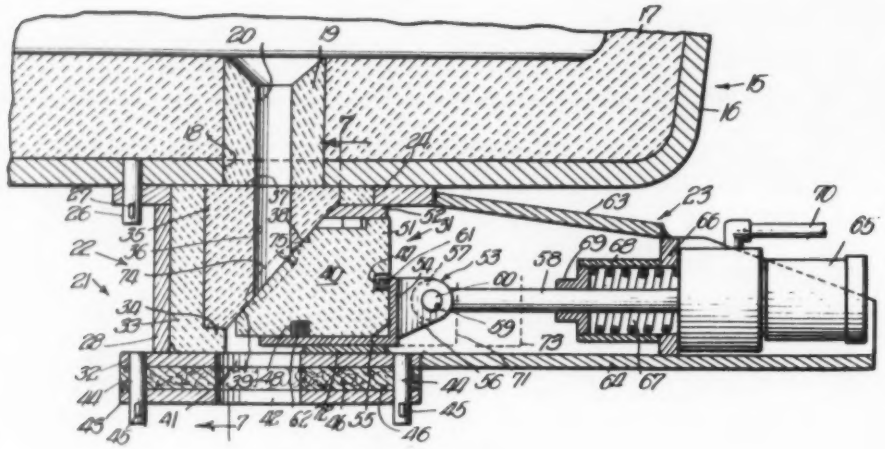


Figure 3

approximating the optimum acid concentration of the bath. A pair of bubbler tubes 14 is installed in the bath to detect changes in the specific gravity in the bath. The bubbler tubes are set so as to register within a narrow range of gravity change in a fashion similar to that of the conductivity cell, and are connected through a recorder-controller 26 with air-operated valve 15. When the gravity reaches a predetermined maximum, valve 15 automatically opens, permtting flow of dilute acid into the bath. Introduction of the dilute acid into the bath lowers the specific gravity, and when the gravity reaches a predetermined minimum, as measured by the bubbler tubes, the valve 15 automatically closes and flow of dilute acid is discontinued. To insure greater accuracy in measuring gravity, a range suppression chamber 27 may be used in conjunction with the bubbler tubes.

LADLE FLOW CONTROL DEVICE

△ U. S. 2,921,351, issued Jan. 19, 1960 to Werner W. Momm, provides an improved form of stopper arrangement for use with ladles.

As shown in Figure 3, the device includes a housing formed from metallic elements divided into a refractory lined portion 22 and a stopper block actuating portion 23. The refractory lined portion 22, is formed from a top ring-like plate 24 provided with circumferentially spaced apertures through which connecting studs 26 carried by the shell 16 extend. Keys 27 attach the top ring 24 and associated housing members to the shell 16.

Within the refractory lined portion 22 of the housing a series of refractory brick elements 33 serve as a heat-resistant lining. The brick segments 33 are provided with inwardly directed flange portions 34 along the bottom edges thereof which support a nozzle 35 of refractory material. The nozzle 35 is cylindrical, vertically directed and provided with a central orifice 36 which is alined with the orifice 20 of the nozzle 19 of the ladle.

The bottom surface 38 of the nozzle 35 is inclined at an angle relative to the horizontal of approximately 54 degrees. The inclination of the surface 38 is designed to provide flush or mating engagement of substantial surface area with a complementarily inclined surface 39 of a block-like body portion 40 forming the stopper block 31. Upon movement of the stopper block 31 out of engagement with the nozzle 35, the molten metal contained within the ladle 15 is free to flow downwardly through the combined orifices 20 and 36, through the central portion of the bottom ring member 32 which defines an opening 41, and down through a registered opening 42 into a suitable receiver.

The block actuating housing portion 23 is formed from a top plate 63 and a bottom plate 64. The bottom wall 64 supports a hydraulically operated cylinder 65. The front face of the cylinder 65 carries a spring mounting ring 66 which defines a seat for an end of a coil spring 67. The spring 67 functions to continuously bias the piston 58, block mounting member 53 and stopper block 31 into closing engagement with the nozzle 35 to prevent flow of molten metal from the ladle 15. The cylinder 65 is provided with a fluid pressure inlet 70 through which actuating pressure is passed to the cylinder 65 to retract the piston rod 58 against the biasing action of the spring 67.

CONTINUOUSLY FORMING WELDED COATED STEEL TUBING

△ U. S. 2,927,371, issued March 8, 1960 to Noble E. Hays and assigned to Armco Steel Corp., provides a method of treatment of a zinc coated metal article in the fabrication of which a welding step has been performed, and as a result of which the coating metal has been melted or burned off in the region of the weld, e.g., as in longitudinal seam welded tubing.

In the practice of the present invention, it has been found that if zinc is sprayed onto the region of the weld immediately after the weld has been accomplished, and while the region of the weld is still at a temperature above the melting point of zinc, the spray applied metal will flow and chemically bond with the adjacent undisturbed coating, and thus form a continuously coated tube.

As shown in Figure 4, a coated

Figure 4

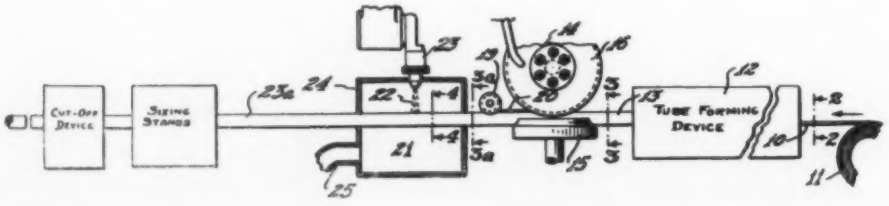
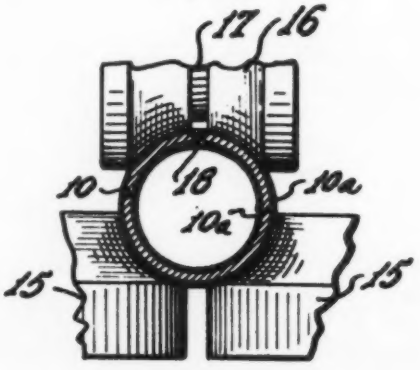


Figure 5



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OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,927,488	3/ 8/60	Rolling mill	Morgan Construction Co.
2,927,489	3/ 8/60	Rolling mill	Schloemann A.G.
2,927,690	3/ 8/60	Apparatus for ore separation	Bolidens Gruvaktiebolag
2,928,164	3/15/60	Method of descaling a rod	John J. Span
2,928,609	3/15/60	Preparation of cellulated slag	S. P. Kinney Engineers, Inc.
2,928,622	3/15/60	Scrap coiling apparatus	The Herr Equipment Corp.
2,928,730	3/15/60	Iron ore reduction process	Inland Steel Co.
2,928,732	3/15/60	Leaching of Mayari ore	Bethlehem Steel Co.
2,929,280	3/22/60	Rolling mill platform	Dorman, Long & Co. Ltd.
2,929,858	3/22/60	Exhaust hood for electric arc furnaces	Zavody Rudych Letnic 1930
2,930,709	3/29/60	Inorganic bonded cores for steel castings	Steel Founders Society of America
2,930,825	3/29/60	Annealing furnace	United States Steel Corp.

metal strip 10 is fed from a coil 11 through a tube forming device 12.

The formed tube 13 then passes through a welding apparatus indicated generally at 14 and which may comprise a pair of rollers 15 and a resistance welding roller 16, as shown in Figure 5. By means of the welding roller 16 which will have the insulated disk 17, a welding current is caused to flow across the joint to be welded and which is indicated at 18. The rolls 15 support the tube from below and offer resistance to the pressure of the welding roller 16. The coating on the strip is, of course, exaggerated in thickness in the drawing and is indicated at 10a.

After the weld has been accomplished, the flash formed in the welding operation is improved or smoothed either by a removal with a scarfing tool or by a rolling down by means of a roller 19.

The welded tubing then passes to a spray apparatus 21 where molten zinc is sprayed at 22 by means of a spray gun 23 onto the region of the weld. The spray operation is carried on within a housing 24 having a fume exhaust duct 25.

The completed tubing indicated at 23 may then pass from the housing 24 through sizing stands, cutoff devices and the like.

DIRECT REDUCTION OF ORE

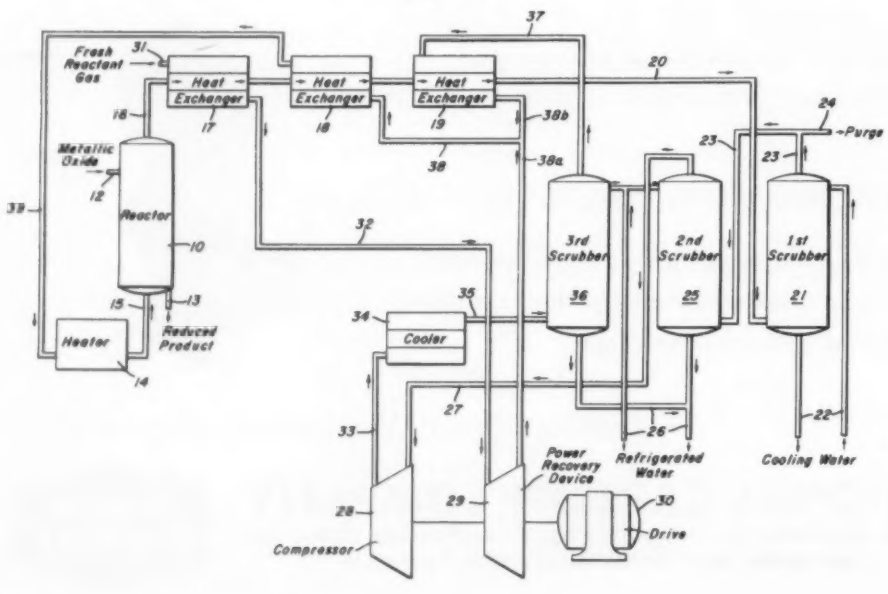
△ U. S. 2,929,703, issued March 22, 1960 to Jagdish C. Agarwal, Fred Kraus, and Theodore R. Roszkowski, assigned to United States Steel Corp. and The Lummus Co., provides a method for handling gases in a continuous direct reduction process for iron oxide ores.

An object is to provide an improved gas handling method and apparatus in which heat is exchanged between the off-gas and the fresh and regenerated gases in multiple stages, thereby utilizing its sensible heat more efficiently.

A further object is to provide a method and apparatus in which off-gas is cooled to as low as 60 F to remove water more completely, a procedure which enhances the reducing power of the gas beyond reasonable expectations.

The process is shown schematically in Figure 6.

Figure 6



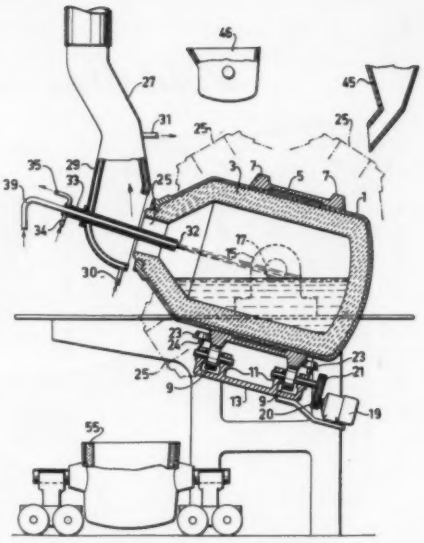


Figure 7

OXYGEN REFINING IN A ROTARY FURNACE

△ U. S. 2,930,688, issued March 29, 1960 to Bo M. S. Kalling and Folke K. E. Johansson, assigned to Stora Kopparbergs Bergslags Aktiebolag, describes a two-stage process of refining silicon-containing pig iron with oxygen in a rotary furnace. The object is to reduce iron losses.

A rotatable furnace of the design shown in Figure 7 and having a capacity of 30 metric tons, was charged with 750 kg of burnt lime and 660 kg of ore together with 27,800 kg of molten pig iron of the following percentage analysis: C = 3.82, Si = 0.75, Mn = 0.76, P = 0.090, S = 0.059.

After charging, oxygen gas with an oxygen content of 97 was blown in with a speed of 50 normal cu meters per min. The oxygen gas was supplied to the space above the surface of the bath by way of a tuyere forming an angle of 23 degrees with the surface of the bath, and the furnace was rotated at 30 rpm in order to provide an intimate mixture of pig iron and slag. After a blowing period of

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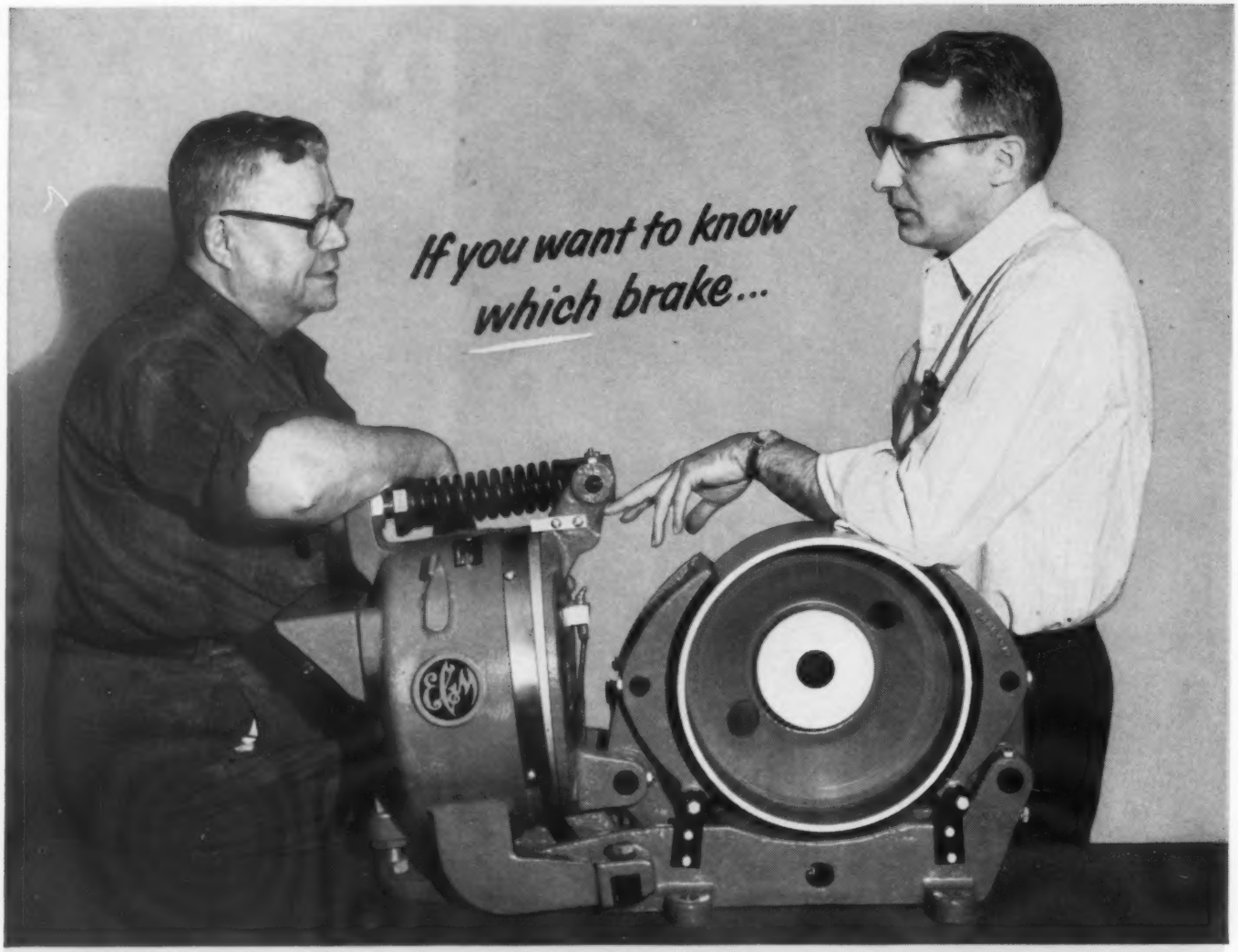

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7½ minutes, the supply of oxygen gas was cutoff but the rotation was continued during another half minute so as to obtain a low iron content in the slag.

After this refining period, most of the silicon content of the pig iron had been oxidized so that the content had decreased to 0.02 per cent and the temperature had risen from 1290 to 1500 C. The silicate slag obtained was of good fluidity and the major part thereof could be tapped out of the furnace. The slag had the following percentage composition: SiO_2 = 36.8, CaO = 42.4, MgO = 7.5, Fe = 2.1, S = 0.165.

After the tapping of the preslag further 1000 kg of lime and 2530 kg of ore were added and then the carbon was oxidized to a content of 0.66 per cent in 17 min. An interruption was then made for checking the carbon content and the steel temperature (1580 C).

At this occassion the slag was not molten due to a low content of iron oxides and silica. After the addition of another quantity of 165 kg of ore, the charge was finally blown during four minutes to 0.09 per cent C and a steel temperature of 1625. Now the slag was molten again and had the following percentage composition: SiO = 15.7, CaO = 44.3, MgO = 11.8, Fe = 14.9, S = 0.222.

After tapping this slag and the steel obtained, the slag was returned to the furnace, replacing part of the ore and lime that had to be charged together with the pig iron when the process was started as stated above.

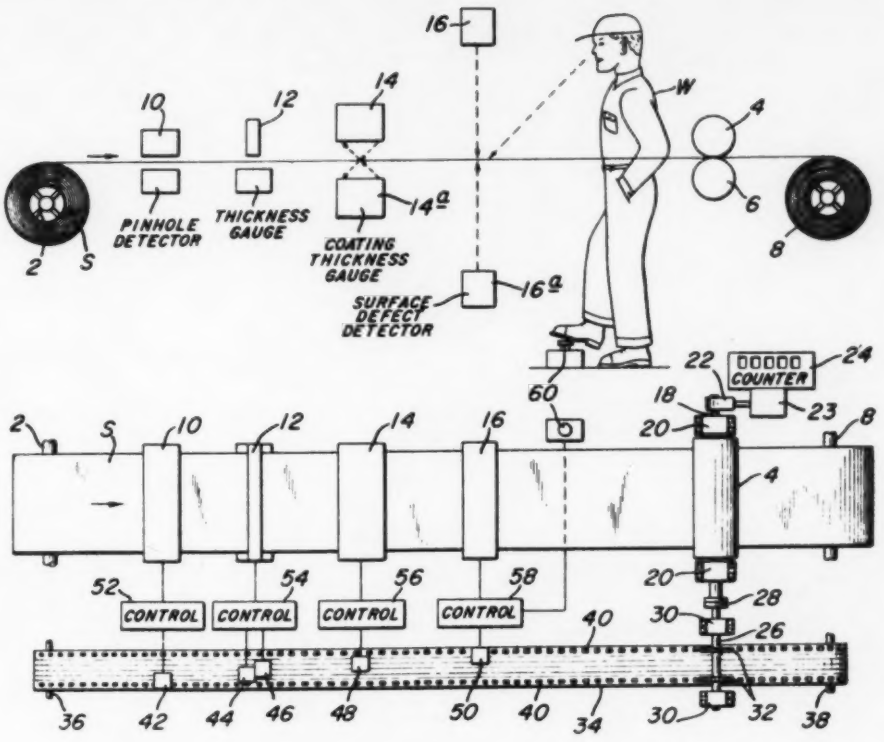

Figure 8

APPARATUS FOR DETECTING AND RECORDING DEFECTS IN A STRIP

Δ U. S. 2,930,228, issued March 29, 1960 to Edward S. Lawrence and Earl R. Muddiman, assigned to United States Steel Corp., relates to detecting and recording of defects in long lengths of coated or uncoated metallic strip. When strip such as steel strip coated with zinc, tin or the like is sold in coil form it is advantageous to the purchaser to know exactly what types of defects are in the strip and exactly where these defects are located. It is especially advantageous if this inspection can be made as the last step in the processing of the strip. Determination of the amount of imperfect strip is also important in determining the value of the strip.

As shown in Figure 8, as the strip S passes between the rolls 4 and 6, cam 22 will rotate to cause the counter 24 to indicate the total length of strip being inspected. At the same time, tape 34 is moved forwardly by engagement of the sprockets 32 in the holes 40. The movement of the tape 34 may be at the same speed as the movement of the strip S, but at any rate must move at a speed having a known relationship with the speed of the strip S. The markers 42, 44, 46, 48 and 50 are located along the path of travel of the tape 34 in positions corresponding to the positions of their related inspection device along the path of travel of strip S. When a pin hole is detected in the strip, the marker 42 will be actuated to apply a suitable mark 62 on the tape 34 at a position corresponding to the exact position of the pin hole. For this defect the marker 42 may be a punch. When the gage 12 detects that the strip is thicker than that desired, the control 54 will operate marker 44 to place a mark 64 on the tape 34. The mark will continue as long as this condition exists. If the gage 12 determines that the strip is undergage, marker 46 will be operated by the control 54 to place a mark 66 on the tape 34. If the coating thickness is under that required, either one or both of gages 14 and 14a will operate the marker 48 through control 56 to apply a mark 68 to the tape 34. The gage 14 determines the thickness of the coating on the top side of the strip and gage 14a the thickness on the bottom side of the strip. If desired, separate markers could be provided for each of the coating thickness gages. When a surface defect on the top of the strip is detected by detector 16 or on the bottom of the strip by detector 16a, the marker 50 will be actuated through control 58 to apply a mark 70 to the tape 34. If the operator W visually detects a defect on the surface of the strip S, he operates the switch 60 to operate the marker 50. Each of the markers, except marker 42, will continue to apply the mark to the strip as long as the defect is present on the strip. Thus, tape 34 records the duration and position of each defect. When the strip S is to be used to make tin cans or other products, it is only necessary to study the tape 34 to determine the position and type of defect.

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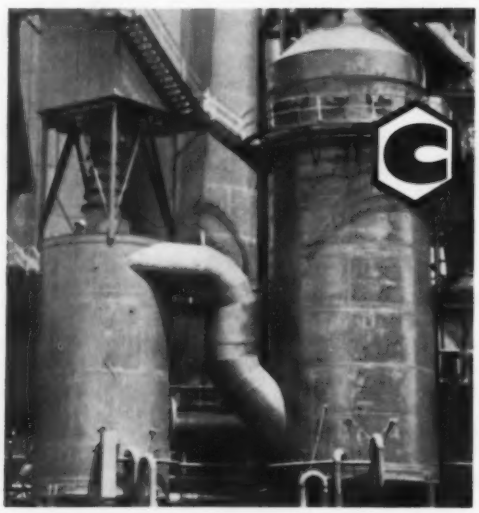

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PARIS
JOHANNESBURG
TOKYO

BETHLEHEM STEEL
New!
Now Bethlehem forges every hardened steel roll from vacuum-degassed steel!

Bethlehem vacuum-degassed steel minimizes the hazard of roll breakage

Pint size, king size, every in-between size. Now Bethlehem forges *every* hardened steel roll from vacuum-degassed steel.

Pioneer in "vacuum casting"

Bethlehem pioneered the development and use of vacuum-degassed ingots for highly stressed applications in the electric power, atomic energy, and other industries.

Our advanced steel-pouring techniques now permit us to pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases (we can also pour directly into a mold in the vacuum chamber). The secondary ladle is then taken out of the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.

Less gas means sounder steel

Because the vacuum-casting method reduces the volume of hydrogen and other gases, the steel is sounder, tougher, and cleaner than air-cast steel. It is this greater internal soundness which reduces the hazard of roll breakage.

Over 350 rolls now in service

In the past several years, we've produced and shipped over 350 large, vacuum-degassed hardened steel rolls. The outstanding performance of these rolls confirms our own production experience, which clearly proves the superior soundness of vacuum-cast rolls as compared to air-cast rolls.

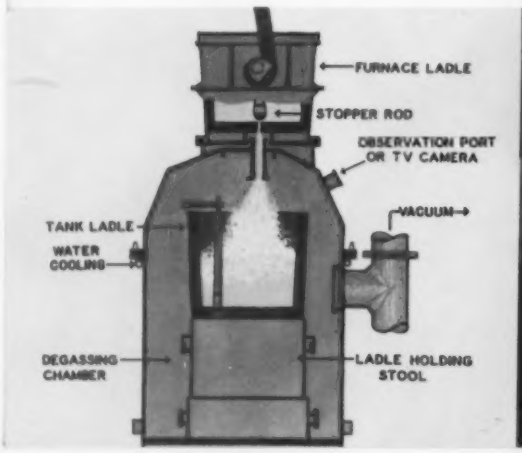
Fast delivery . . . no extra cost

You have everything to gain (less roll breakage), nothing to lose (no price extra) by making your next purchase of hardened steel rolls Bethlehem vacuum-degassed rolls. Deliveries are excellent. Our sales offices are ready to give you the *whole* interesting story of this new Bethlehem development. Call or write the office nearest you today. Or write to us at Bethlehem, Pa.

STEEL IS TAPPED from the furnace into the furnace ladle. The furnace ladle is then attached to the vacuum tank, and the molten metal pours through a vacuum-tight seal into either a secondary ladle or a mold inside the degassing chamber. If poured into a ladle, ingots can be subsequently cast from this ladle under a blanket of inert gas.

TV TELLS HIM WHAT'S GOING ON. One TV camera peers inside the high-vacuum chamber into which the hot steel is gushing and shows the stream coming from the furnace ladle (top screen). Another camera, whose picture appears on the bottom screen, shows the action of the hot steel as it flows into either the secondary ladle or the mold set up inside the vacuum tank.

ULTRASONIC SOUND WAVES, pitched so high you can't hear them, penetrate every inch of the Bethlehem vacuum-degassed roll you see here. The waves relentlessly search out any possible inner discontinuities which, if present, would be indicated on the screen. When the Bethlehem inspector gives his OK, you can rely on the soundness of that roll.



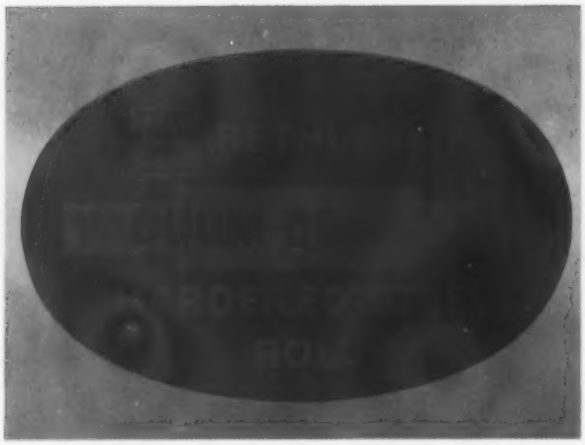
BETHLEHEM VACUUM-DEGASSED ROLLS are made for every application—cold-rolling steel sheet, strip, tinplate, and non-ferrous metals. Every roll meets your specifications *exactly* on size, shape, hardness, and finish.

BETHLEHEM STEEL

BETHLEHEM STEEL

CHECKING EVERY DETAIL is more than a routine habit in the making of Bethlehem vacuum-degassed forged rolls. It's done with an extra measure of thoroughness, extra care—from the analysis of the steel to the critical inspection of the finished product.

These are the new symbols of quality for hardened-and-ground forged steel rolls



LOOK FOR THIS LABEL on the packing of the hardened steel rolls you buy. It's your guarantee that your rolls are forged from Bethlehem vacuum-degassed steel . . . steel that minimizes the hazard of roll breakage in your plant.

LOOK FOR THIS "V" STAMP on the ends of the rolls you buy. . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll from now on . . . because from now on Bethlehem forges hardened steel rolls *only* from vacuum-degassed steel.

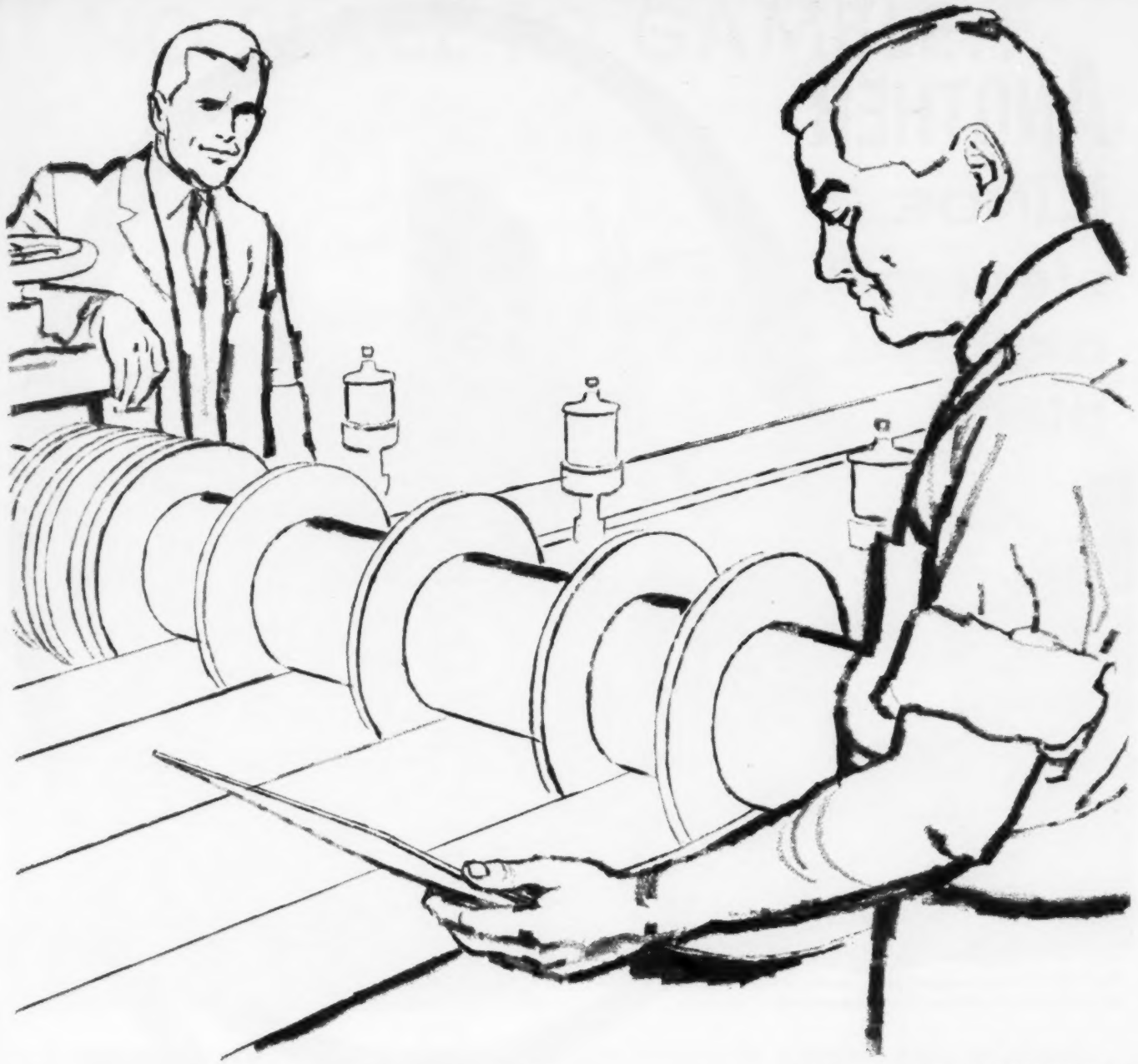
Steel

For strength
. . . economy
. . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



Can you get longer edge life from your SLITTER KNIVES?

A·S·K for the answer!

AMERICAN SHEAR KNIFE

The answer is yes when you use slitter knives from A.S.K. (American Shear Knife Company). A.S.K. Slitter Knives last longer, stand up better under the heaviest jobs, reduce maintenance and replacement costs!

Why? Because A.S.K. has devoted years of research to the selection of proper alloys, and correct techniques in heat treating, precision grinding. For slitter knives that last longer, improve your slitting operation . . . Ask A.S.K.!

FREE HANDBOOK—Want a handy reference on the installation, operation and maintenance of slitter, shear and chipper knives? A.S.K. has the answers in an 88-page manual. For free copy, write American Shear Knife Co., Homestead, Pa.

ANOTHER LINDE steel mill oxygen plant

This 500-tons-a-day oxygen plant, shown here under construction, is now on stream.

...with no capital investment

Steel producers are buying more and more LINDE oxygen. Since 1955 LINDE has put on-stream close to an average of one plant a month, most of them feeding oxygen to steel's furnaces. The 500-tons-a-day plant shown above is one of these.

Steelmen like the system—

- Because LINDE invests the capital, pays the labor, buys the power, and guarantees oxygen supply for steelmaking.
- Because steelmen make the steel—and LINDE makes the oxygen.
- Because steel money buys steel facilities—and LINDE buys oxygen capacity.

Right now, LINDE is building more than $50,000,000 worth of new oxygen facilities. Production will soon begin at new or expanded facilities at 16 locations. Oxygen capacity will jump by more than 4,000 tons a day.

This means—more single customer plants . . . more liquid oxygen to back up those on-site plants.

Absolute dependability—

Every plant has to be shut down some time. But, there are more than 100 locations where LINDE is producing or has bulk quantities of liquid oxygen in storage. This is a degree of *back-up insurance* no one else can approach.

For your *guaranteed* supply at lowest possible overall cost, call LINDE COMPANY, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Ontario.

LINDE COMPANY **UNION CARBIDE**

LINDE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

NO PLACE TO GAMBLE...

TAPECOAT®
is Your Best Bet
to Protect Mill Lines
in Underground Service

Joints on this water line at steel plant are TAPECOATED to provide protection equivalent to coating on the pipe.

You take no chances when you specify TAPECOAT coal tar coating in handy tape form for pipe, pipe joints, fittings, couplings, tanks, tie rods and conduit on new construction, as illustrated, or for preventive maintenance on replacements.

Since 1941, TAPECOAT has proved its superiority in resisting moisture, acids, alkalis, chemical fumes and other severe corrosive and abrasive conditions.

For example, failure of a water line at an eastern steel plant in 1946 prompted this producer to turn to TAPECOAT for protecting the new line. Results were so conclusive that they have since standardized on TAPECOAT for wrapping fire prevention, water, gas and fuel lines in sizes ranging from 2″ to 48″.

TAPECOAT comes in rolls of 2″, 3″, 4″, 6″, 18″ and 24″ widths. It is easy to apply with the use of a torch. No skilled help required.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for details today.

The TAPECOAT® *Company*

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

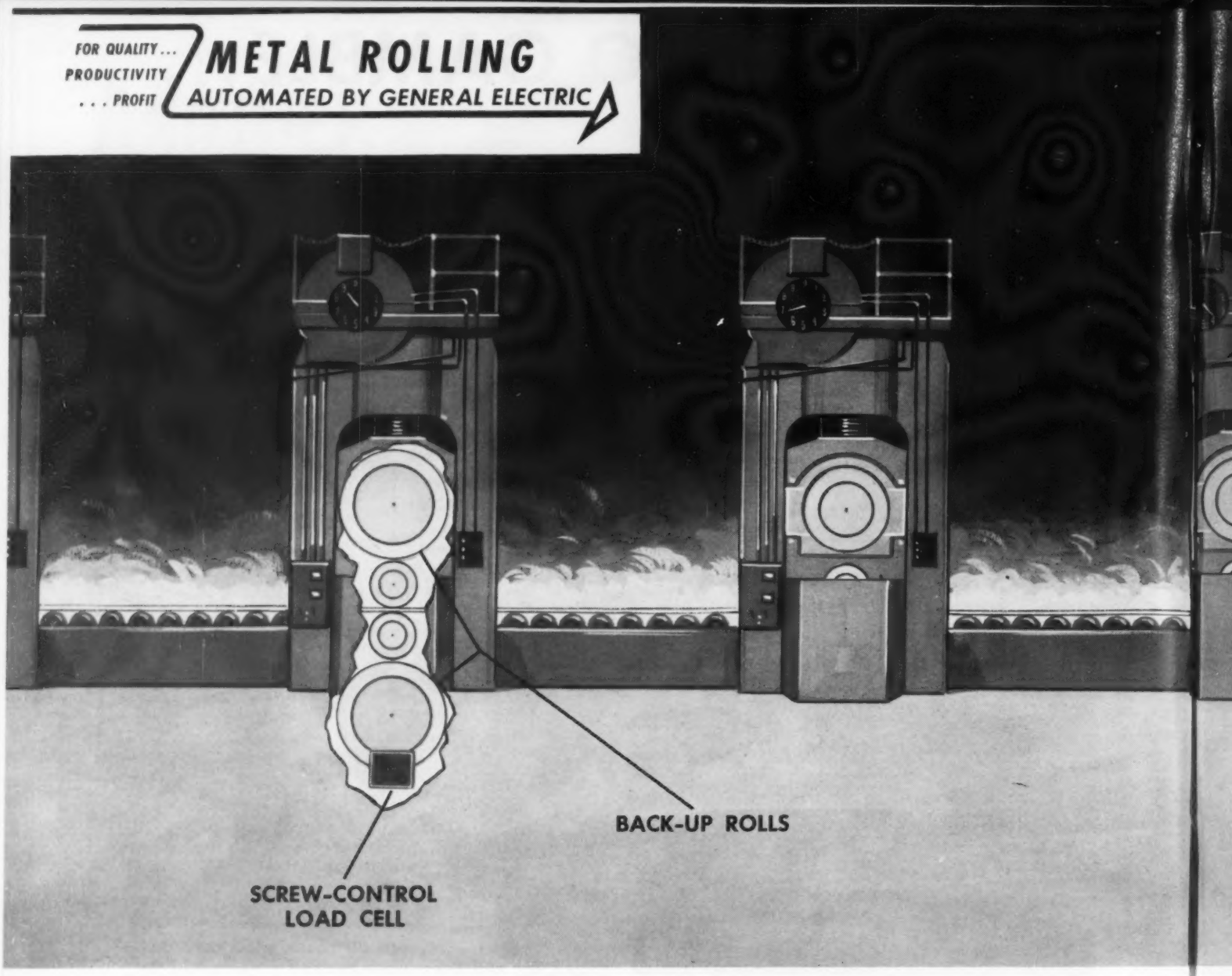
1541 Lyons Street, Evanston, Illinois

Representatives in Principal Cities

Manufactured and distributed in Canada by The Tapecoat Company of Canada, Ltd., 25 Haas Road, Rexdale, Ontario

FOR QUALITY... PRODUCTIVITY ... PROFIT

METAL ROLLING
AUTOMATED BY GENERAL ELECTRIC



AT USS GENEVA WORKS

G-E automatic gage control maintains

A new, vastly improved method of automatically controlling gage on hot-strip mills is available now. Greater strip uniformity and increased yield per ton of steel will result from use of this thickness control system, developed jointly with U. S. Steel Corporation engineers, and now installed at USS's Columbia-Geneva Steel Division, Geneva Works, Provo, Utah.

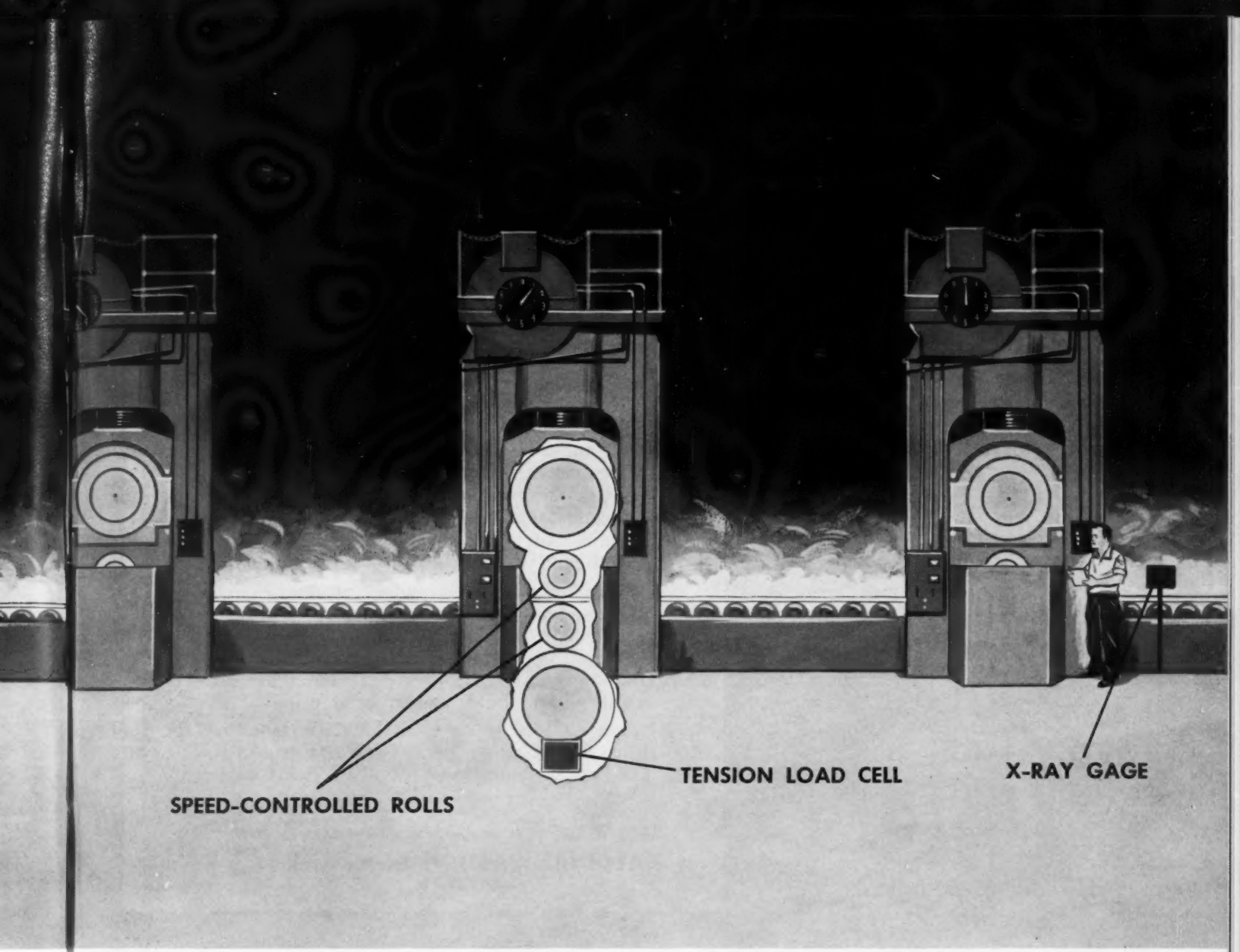
HOW UNIFORMITY AND YIELD ARE CONTROLLED

The system operates on the basis of off-gage steel automatically correcting itself by "triggering" the control to change the roll settings and inter-stand tension. As the temperature or gage of the strip being fed to the mill varies, the pressure against the rolls varies. At the second stand, this change in pressure is detected by the load cell where it is converted into power to move the screwdown motors. This entire operation is completely automatic and is initiated in a fraction of a second.

At the fifth stand, the same detection system is used to recheck the gage of the strip. However, at this point, the correction is made by adjusting the speed of the rolls, rather than their position. This controls the tension of the strip on either side of stand five, depending upon the correction required.

Automatic correction for hot and cold spots—As hot and cold spots pass through the mill, the control "feels" the difference in the hardness of the strip and automatically adjusts inter-stand tension to maintain a constant gage.

Strip "tail" is rolled to gage—The "tail" of the strip is often off-gage as a result of loss of tension as the end of the strip passes through the mill. The gage control



strip uniformity—increases yield

system adjusts the rolls or inter-stand tension to compensate for this loss of tension and rolls the "tail" to closer tolerance thickness, resulting in less scrap and greater yield.

Automatic correction for long-time drift—An x-ray thickness gage is normally used in conjunction with the control. The x-ray continuously measures the gage of the strip, and automatically makes corrections to compensate for thermal effects and mill drift.

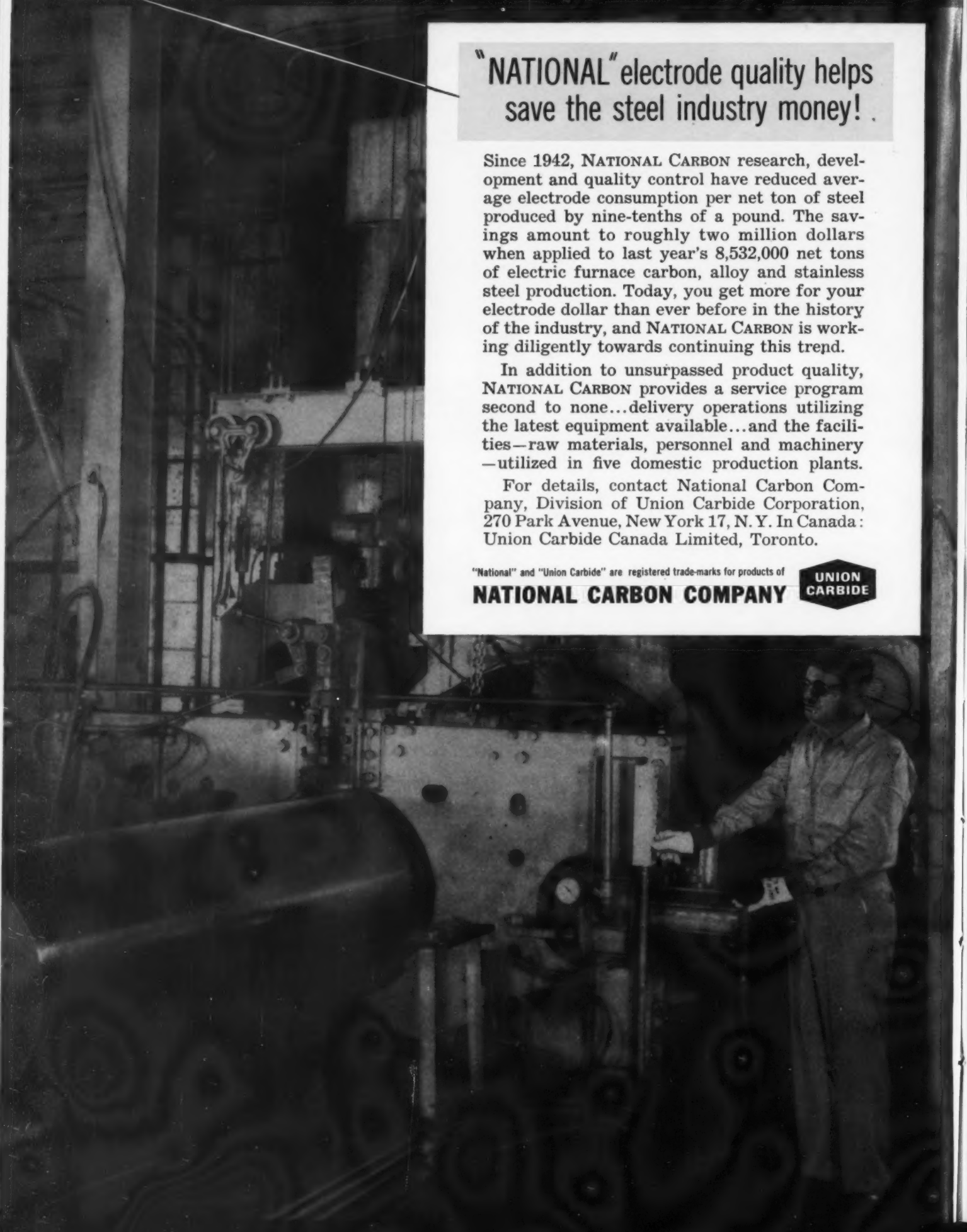
For complete details on this new gage control method, contact your G-E Apparatus Sales Engineer today, or write to Section 785–8, General Electric Company, Schenectady, N. Y., for bulletin GEA-6947. Industry Control Department, Salem, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC

MAJOR REASONS FOR SPECIFYING NATIONAL ELECTRODES...

QUALITY SERVICE · DELIVERY · FACILITIES!



"NATIONAL" electrode quality helps save the steel industry money!

Since 1942, NATIONAL CARBON research, development and quality control have reduced average electrode consumption per net ton of steel produced by nine-tenths of a pound. The savings amount to roughly two million dollars when applied to last year's 8,532,000 net tons of electric furnace carbon, alloy and stainless steel production. Today, you get more for your electrode dollar than ever before in the history of the industry, and NATIONAL CARBON is working diligently towards continuing this trend.

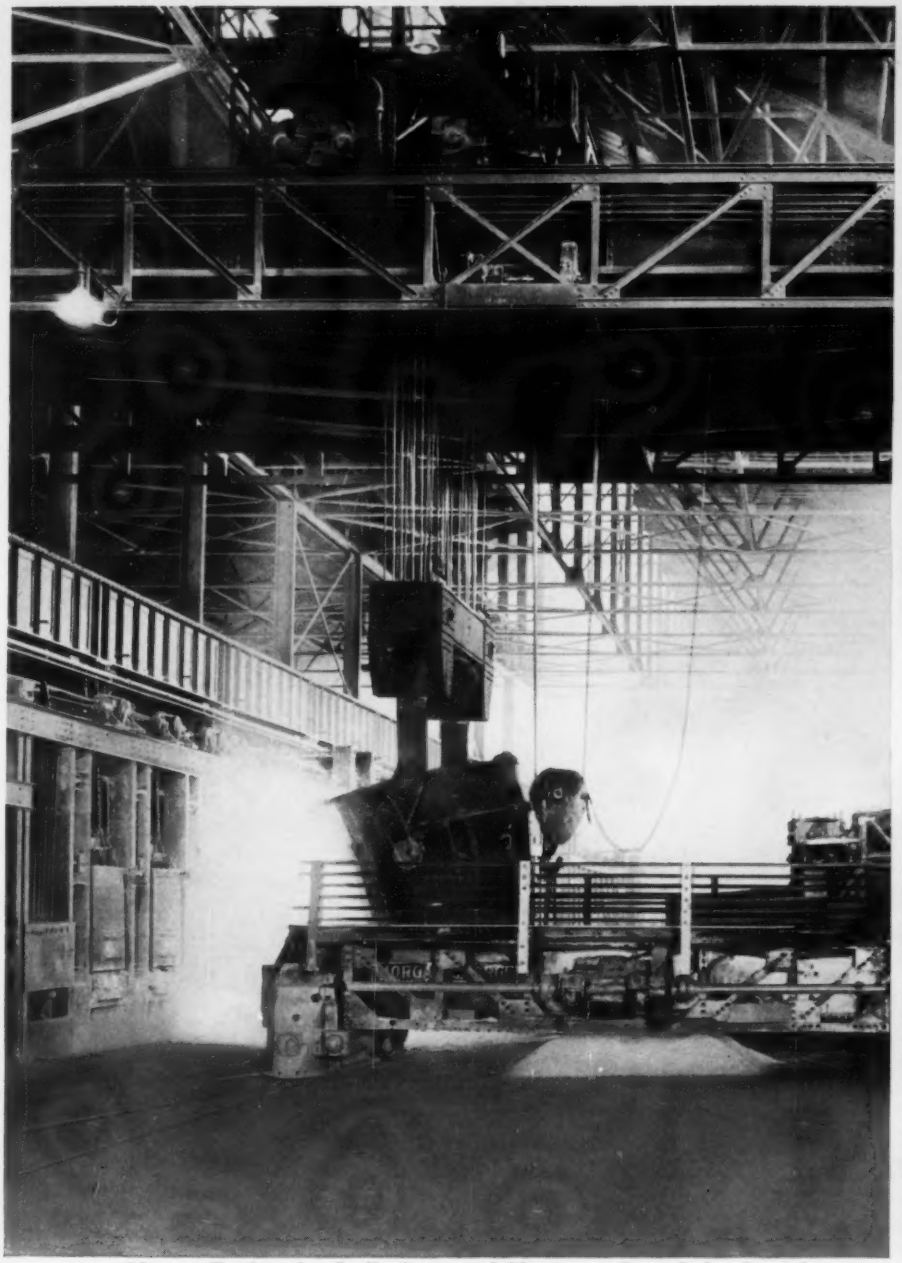
In addition to unsurpassed product quality, NATIONAL CARBON provides a service program second to none...delivery operations utilizing the latest equipment available...and the facilities—raw materials, personnel and machinery—utilized in five domestic production plants.

For details, contact National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

"National" and "Union Carbide" are registered trade-marks for products of

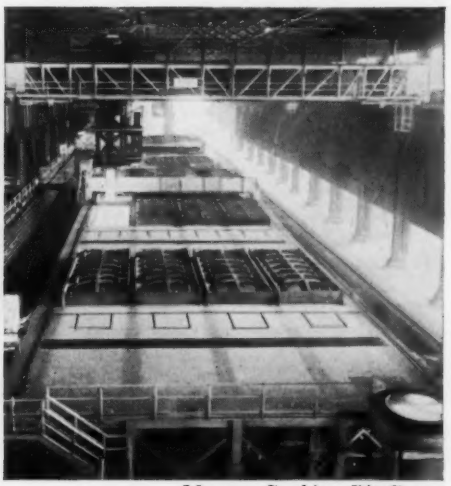
NATIONAL CARBON COMPANY

UNION CARBIDE



Morgan Engineering Ladle Crane and Charger at Great Lakes Steel Company, Ecorse, Detroit, Michigan

Morgan Teeming Ladle Crane



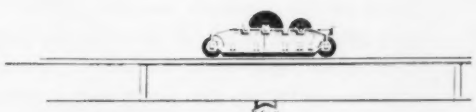
Morgan Soaking Pit Crane

At Great Lakes Steel...

NEW MORGAN CRANES SUPPLEMENT THE OLD TO BOOST OUTPUT

From scrap to finished steel, Morgan Engineering cranes and chargers keep metal on the move. Having served them faithfully in past years, Morgan equipment was again selected by Great Lakes Steel for their latest expansion program.

Where your metal handling calls for top reliability to keep production flowing, low operating and upkeep costs to keep profits up, call for a Morgan representative. He'll advise you on the most economical equipment for your purposes.



THE MORGAN ENGINEERING CO. *Alliance, Ohio*

Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws, auxiliary equipment and welded fabrications.

SALES OFFICES: 1754 North Highland Road, Pittsburgh 28, Pennsylvania
30 Church Street, New York 7, New York

Bearings, Inc. recommended a better seal, a better bearing and savings are $700.00 a year!

Here's a maintenance foreman who knew where to get help when bearings in his care failed prematurely. He called a Bearings, Inc. engineer when the bearings in this bucket elevator conveyor failed after only two weeks of use.

The Bearings, Inc. engineer found that the powdered zinc transmitted by the conveyor was responsible for the failure. Powdered zinc had worked through the bearing seal and since zinc joins itself when rubbed between two surfaces, being rubbed between the balls and bearing race led to a build-up that stopped the bearings in their tracks.

Analysis of loads and speeds showed a less expensive bearing would work well if its seal would shut out all dirt. The original bearings cost $16.79 each — the replacement only $7.36! This meant a net saving of $700 in bearing costs alone. Now in operation for two years the bearings have been replaced only once.

Bearings, Inc. sales engineers sell only products we are authorized to sell. No deals, no "just as good as" substitutes. Call the branch nearest you — The bearings you want are in stock ready for delivery.

Providing bearing service in the North → **BEARINGS, INC.**

DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Ft. Wayne • Indianapolis • Muncie • Terre Haute • **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark • **NEW YORK:** Balanrol Corp., Buffalo • Niagara Falls • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York • **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

and

in the South → **DIXIE BEARINGS, INC.**

ARKANSAS: Little Rock • **FLORIDA:** Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge New Orleans • **N. CAROLINA:** Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville Memphis • Nashville • **VIRGINIA:** Norfolk • Richmond • Roanoke

Femco, Inc.

MAIN OFFICE AND PLANT
IRWIN, PENNSYLVANIA
Telephone UNderhill 3-3200

Let's come down to earth
about Steel Plant automation.

Possibly the concept of a "completely automated steel plant" by 1970 is entirely correct. Even so, it will be many, many more years before the industry can afford to scrap its present facilities and spend the billions of dollars needed for enough dream plants to meet steel demand.

Meanwhile, steel men face the problem of getting more efficient production now.

FEMCO believes that the solution to this problem lies in a combination of automatic and remote control applied to present individual operations.

Automatic, because certain portions of the "work cycle" in many operations are repetitive, such as movement of a quench car from the oven to the quench tower and thence to the coke wharf.

Remote Control, because many portions of the work cycle must be varied to meet varying conditions. Human judgment is required - and remote control is the most efficient method of putting an operator's decisions into effect.

It has been our privilege to design and build many types of systems for many operations in steel plants of every size in the United States and abroad. These installations are convincing evidence that you share our confidence in this approach to your problem.

We will be glad to tell you about what we have already done for others - and we hope you will continue to challenge us with new problems in the future.

FEMCO, INC.

W. P. Place, President

COMMUNICATION • *Electronic Engineers* • AUTOMATION

A-102

SCHLOEMANN

Five-Tube Tester

1. Singly movable heads
2. Jointly movable heads
3. Movable carriage
4. Charger and discharger
5. Prefill-water station
6. Pressure water station
7. Control desk

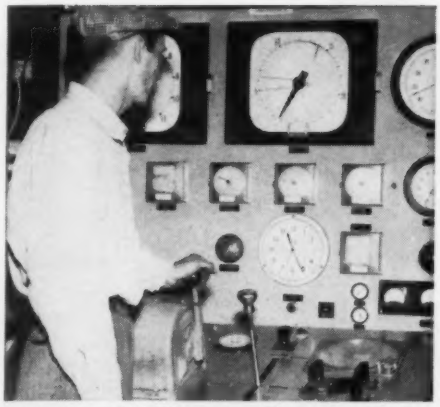
Photo: Courtesy of Jones & Laughlin Steel Corp.

Up to 1,200 tubes per hour • In operation in the U.S.A.

Tubes of varying lengths and diameters can be tested automatically on SCHLOEMANN's new five-tube tester. Two standard models are available – one for tubes ½ in. to 2 in. i.d., 17 ft. to 25 ft. long and another for tubes up to 4 in. i.d. and 50 ft. in length. Special design permits rapid change-over to different tube sizes. Maximum testing pressure 1,500 PSI (25 ft. model), 2,300 PSI (50 ft. model). – Electro-hydraulic pre-set controls. *For further details send for leaflet 31/1e.*

FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

HOT AND COLD ROLLING MILLS • COUNTERBLOW HAMMERS • HYDRAULIC PRESSES



Bristol Electronic Dynamaster* Potentiometers (top left on panel) and Bristol Metagraphic Miniatures (directly under Dynamasters) on control panel at Dofasco. Bristol instruments at Dofasco monitor such important variables as oxygen pressure and flow (current rate and total), lance position and lance cooling water temperature, flow and pressure and other temperatures.

**T.M. Reg. U.S. Pat. Off.*

Growth of oxygen steelmaking is one of the most exciting steel-industry advances during the past decade.

And Bristol instruments are playing an ever increasing part in this production revolution—from the first basic oxygen (L-D process) steelmaking plant on the North American Continent (see photos) to oxygen-using modifications of open-hearth furnaces, bessemer converters, and electric furnaces.

Here are just a few of the important variables Bristol instruments measure, indicate, record, or automatically control in modern oxygen steel plants: Oxygen pressure and flow (current rate and total), oxygen lance position, lance cooling water temperature, flow and pressure, fuel (coke-oven, natural gas, oil) flow, totalized flow and pressure—as well as complete telemetering and dispatching-center instrumentation for both fuel and oxygen pipelines.

A complete line of Bristol pyrometers—radiation, thermocouple and resistance models—and accessories are offered for every temperature range ... from −125° F to 5000° F... in every kind of steel plant.

Get complete data! Before committing your steel plant to *any* modernization program, find out how *Bristol* can solve your instrumentation problems. Write: The Bristol Company, 123 Bristol Road, Waterbury 20, Conn.

O.30

Instruments for oxygen steelmaking... by Bristol

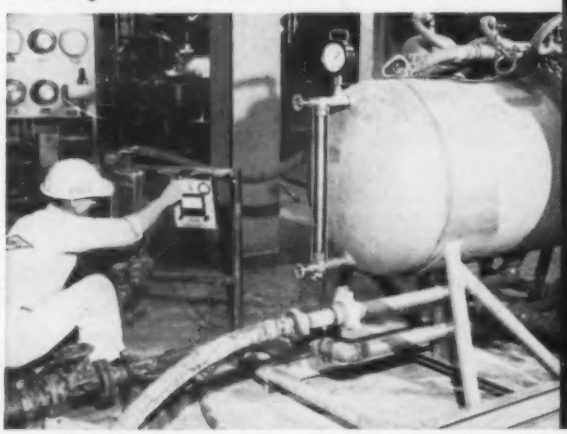
First basic oxygen steelmaking plant in North America at Dominion Foundries and Steel, Ltd., (Dofasco) at Hamilton, Ontario, Canada. Oxygen plant in foreground; steelmaking plant in distance. Bristol instruments play an important part in this pioneering operation.

BRISTOL ...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

A new mark for a nation-wide cleaning service . . . DOW

Jetting tool cleans tubes fouled with coke and asphalt.



New mobile foam-cleaning equipment cuts cleaning costs.

Cleaning missile lines and components requires tolerances as close as 150 microns.

DOW INDUSTRIAL SERVICE

Industrial Cleaning. Dow Industrial Service, now a separate division of The Dow Chemical Company, offers the only nation-wide chemical cleaning service for virtually all types of industrial processing equipment. This is an expansion of the cleaning service developed over the past 20 years. Dow is currently servicing entire plants as well as doing special cleaning jobs for both large and small companies.

Dow Industrial Service research in industrial chemical cleaning has developed specialized mobile equipment and techniques, some of which are pictured above. These highly efficient techniques are improving plant productivity and reducing equipment downtime in all industries using steam generators, condensers, heat exchangers, towers, water and product lines, water wells and tanks, or similar process equipment.

Product Sales and Service. The sale of specialized chemical products, scientifically formulated to be of use in specific industrial processes and to give the necessary technical service in their use, is the job of Product Sales and Service. Purifloc* N17 is an outstanding new flocculant cleared by USPHS for use in potable water.

Laboratory Service. Because of the rapid development of chemical products for the municipal and industrial waste and water treatment areas, Dow Industrial Service will take on the service-selling of those products. Also, a consulting laboratory service for municipal and industrial waste and water treatment is provided.

You'll find Dow Industrial Service offices and stations with specialized cleaning equipment and experienced personnel in all major industrial areas. For more information, write to Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio. *TRADEMARK

DOW INDUSTRIAL SERVICE DOW *Division of THE DOW CHEMICAL COMPANY*

Are you satisfied with your ingot car maintenance costs?

This mark tells you a product is made of modern, dependable Steel.

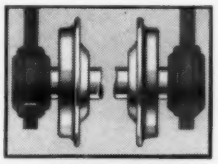
These rugged 8-wheel Ingot Mold Cars haven't had one single repair job since they were bought *six years ago!* Yet they work like new. Each car is designed with an all-welded steel body that offers long life and dependable service. United States Steel has the facilities, the skilled engineers and the technical know-how to build *strong* industrial cars. You give us your specifications and requirements, and we'll design for you the finest industrial cars in the world. We would appreciate an opportunity to discuss this personally and in greater detail. To arrange a meeting write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. or any of our District Offices.

USS is a registered trademark

Here's how USS Industrial Cars are built better:

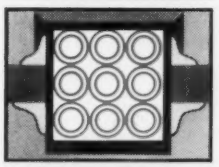
ANTI-FRICTION OUTBOARD BEARINGS:

High-capacity anti-friction bearings are located outside each of the car's eight wheels to minimize sidesway and to provide long, smooth-running performance.



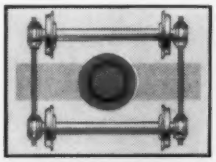
SEVENTY-TWO COIL SPRINGS:

Eighteen coil springs on each side of both trucks provide a total of 72 separate springs for a shock-absorbed level ride.



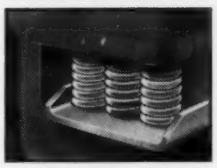
HIGH ENGINEERING SAFETY FACTOR:

Designed for a 200-ton normal capacity load —including ingots, molds and stools —each car has a substantial built-in safety factor to withstand maximum ingot-stripping thrusts.



OVERSIZE CENTER PLATES:

"Beefed-up" center plates between the trucks and car body are 18 inches in diameter—compared with the conventional 12 inches—to reduce the load per square inch on their surfaces.



HOT-METAL SHIELDS:

Curved end plates, long side skirts, and special drip shields protect the couplers, bearings and springs from runover molten metal and troublesome solidified drippings.

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

National's Deac Scholl, sales manager, and Bill Curran, works manager, talk rolls by one of the largest ever cast, a 38½x160" plate roll.

Another example of National Roll quality control

We "live" with your rolls after shipment, too

National Roll has only one business: rolls. This product concentration has enabled National to build a sales, service and production staff with specialized knowledge of roll making. Experienced men give every roll order placed with National "personalized" attention, all the way from consultation with the customer before the order is placed to follow-up on the roll's performance throughout its service life.

This emphasis on customer service is one reason for the confidence so many steel makers are placing in National as a supplier of steel, nodular iron and cast iron rolls.

A new brochure entitled "This is the New National Roll" explains many more of National's unique advantages as a roll supplier. We will be glad to send you a copy. It shows you why . . .

National's the growing name in rolls

NATIONAL ROLL & FOUNDRY DIVISION

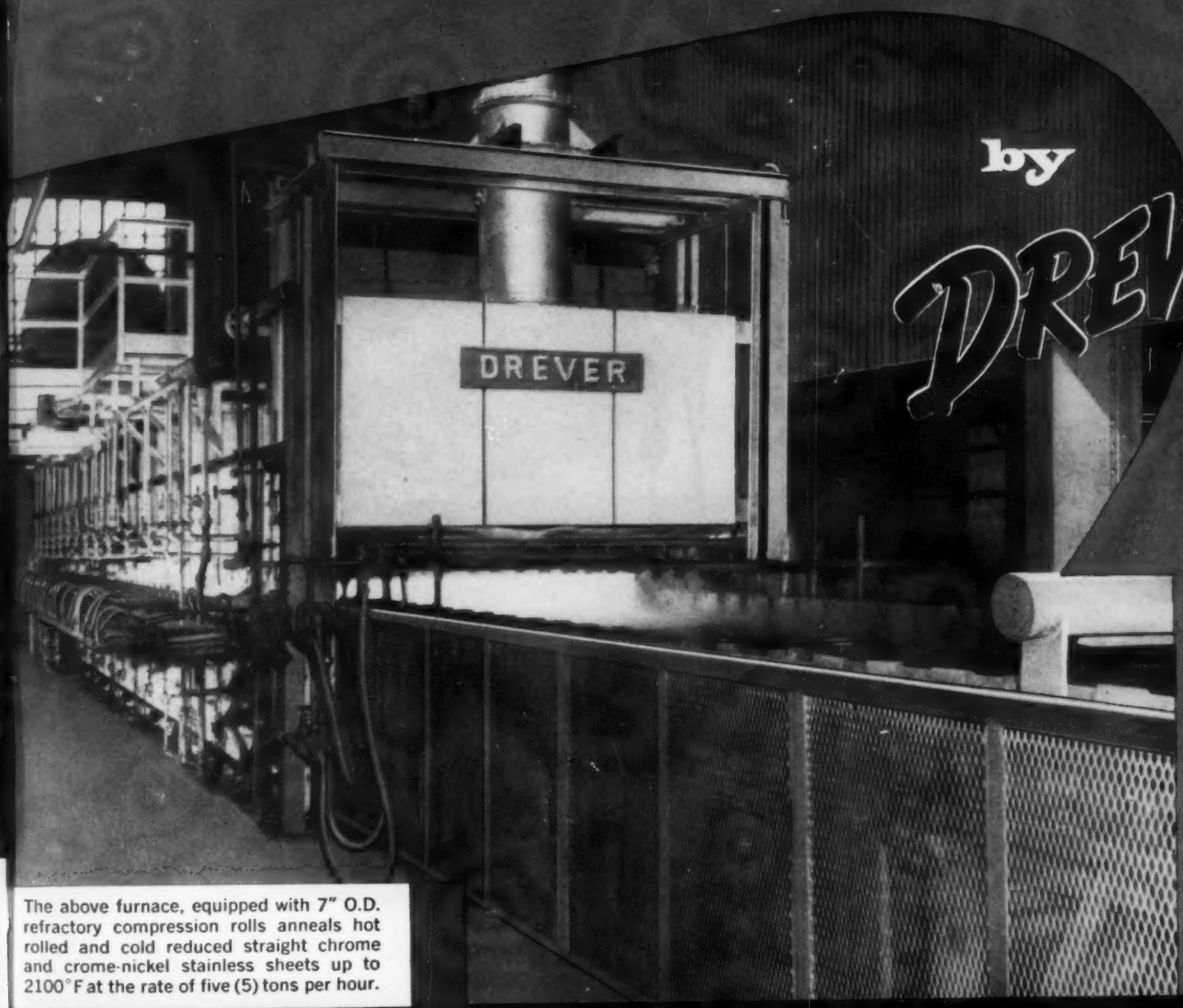
GENERAL STEEL CASTINGS CORPORATION, Avonmore (Westmoreland County), Pa.

General Steel Castings Corporation, General Offices: Granite City, Illinois • Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.

ROLLER HEARTH FURNACES

for Operation at 2300°F Utilizing Drever Refractory Compression Rolls

by DREVER



The above furnace, equipped with 7" O.D. refractory compression rolls anneals hot rolled and cold reduced straight chrome and crome-nickel stainless sheets up to 2100°F at the rate of five (5) tons per hour.

The success in utilizing the Drever Refractory Compression Roll in annealing stainless steels has been attributed to the roll strength and its resistance to pickup which completely eliminates the necessity of using rider sheets. The refractory rolls are prestressed and consist of silicon carbide sections retained by spring loaded alloy ends to allow for expansion and to provide axial forces to insure structural stability under rated load. Furnaces have been installed with roll sizes varying from 4½" O.D. x 20½" long to 14" O.D. x 14'-6" long.

In addition to annealing stainless steel sheets, plates, bars and tubing, materials have been successfully heat treated at 2300°F. Avail yourself of the experience of Drever Company engineers in solving your stainless steel annealing problems.

DREVER COMPANY

RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

Engineering and Manufacturing Facilities Around the World through Associates in France, Great Britain, Germany, Italy and Japan

The warning that comes too late!

WHEN THIS HAPPENS, it's already too late. Lubricant has leaked out, and dirt or grit have probably damaged your bearings and shaft.

You can avoid sealing problems by using Johns-Manville Clipper Seals because you can count on them to outlast time between regular overhauls. They seal efficiently . . . give better protection. That's why Clipper Seals are selected as original equipment by many automotive, marine and aviation manufacturers.

JOHNS-MANVILLE PRODUCES a wide range of sizes and lip designs—including Split Clipper Seals for quick, temporary replacement — in compounds that will resist every heat, speed or corrosive condition. It is smart maintenance practice to use Clipper Seals, and to keep on hand a small replacement stock of the sizes and designs you need regularly.

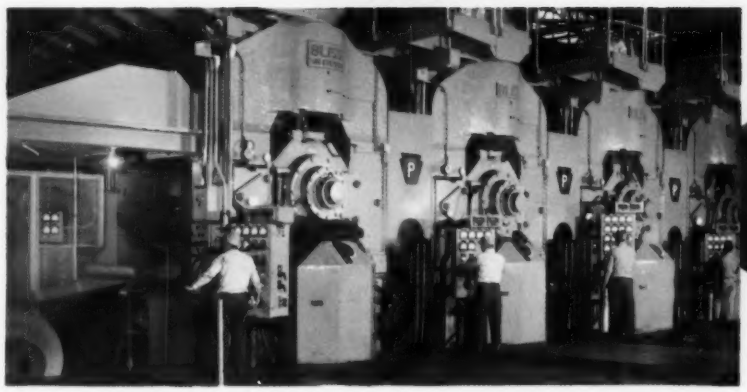
Let your J-M Distributor help you select the Clipper Seals that are compounded to meet your exact sealing requirements. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE
CLIPPER SEALS

JOHNS-MANVILLE JM PRODUCTS

A.

B.



C.

D.

Many of the world's most modern tandem cold-reduction mills carry this trade-mark . . .

BLISS
SALEM OHIO

A. Fastest, most powerful mill of its kind: Delivery speed of 3800 feet per minute and 24,000 connected horsepower make this the fastest, most powerful cold-reduction mill of its type in the world. It rolls steel strip in widths up to 72″ in coils as heavy as 60,000 pounds.

B. Large tonnage orders or a few coils: Versatility is the design keynote of this Bliss tandem mill. Strip ranges up to 48″ width. Tension reel, coil buggy and horizontal belt wrapper handle coils weighing as much as 34,000 pounds.

C. Speed and precision of control: This big Bliss tandem mill rolls a variety of steels, including stainless and tinplate, delivering strip at speeds up to 3200 fpm in widths to 60″ in coils as heavy as 60,000 pounds. Special electronic controls detect gage variations of .001″, reset rolls in split-seconds.

D. First of its kind: This Bliss tandem mill will have a planned fourth stand added later this year. The mill rolls steel strip up to 60″ width; was the first multiple-stand cold-reducation mill in the country in which it is installed.

BLISS
SINCE 1857

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

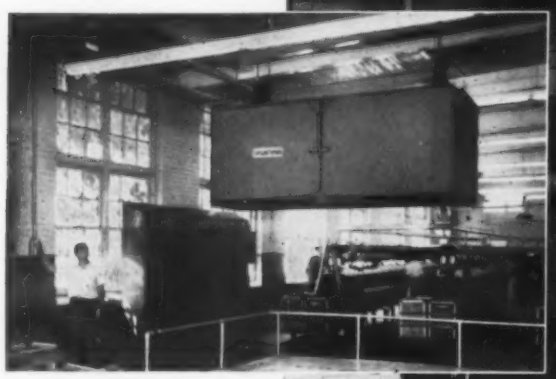
Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

Write for your complimentary copy of our 84-page Rolling Mill Brochure, Bulletin 40-B.

Automatic Handling System Brings **BIG SAVINGS**

Operates Between Buildings Without Operator

A Tramrail freight-carrying van leaving one building. Building doors open and close automatically. Tramrail track is high and above interference with railroad. The entire handling system is very safe.



Operator pushes wall button to start van on its way. Van rises until it reaches Tramrail carrier on track. Then carrier hauls van to building selected.

RAIN or shine, this Cleveland Tramrail system works without complaint. Inclement weather is of no concern, because no one has to go outside to operate this system.

The Tramrail freight-carrying van travels between buildings as directed by the touch of a pushbutton. It goes up and down grades and handles materials between different floor levels.

No regular operator is needed for this type of system. Usually the time required to dispatch loads is so little that production workers can do this along with their normal duties.

Great savings are made with Cleveland Tramrail automatic handling systems. They cut handling time enormously. They operate overhead above usual floor traffic and hindrances. They save floor space. They eliminate expensive floor repairs which floor conveyances make necessary. Tramrail equipment requires far less maintenance than usually is necessary with other types of conveying equipment.

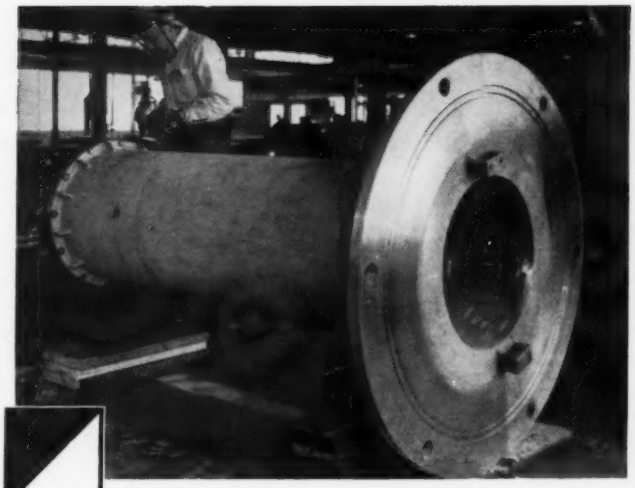
Because the dividends are large and immediate when you install a Cleveland Tramrail automatic handling system, it will be to your interest to get the facts on what Cleveland Tramrail engineers can do for you.

CLEVELAND TRAMRAIL

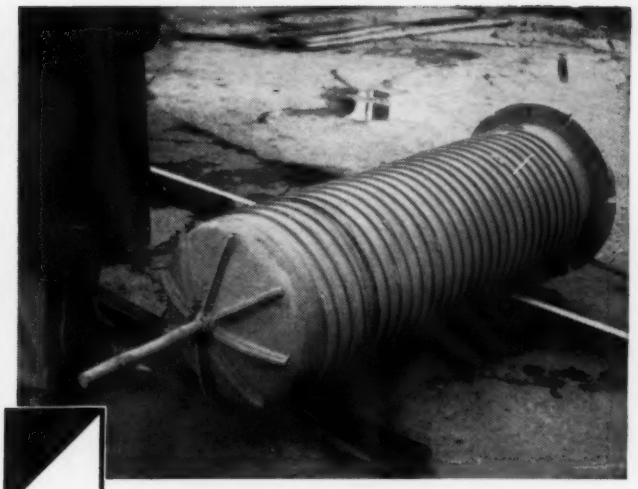
Overhead Materials Handling Equipment

Write for free "Automatic Handling" booklet.

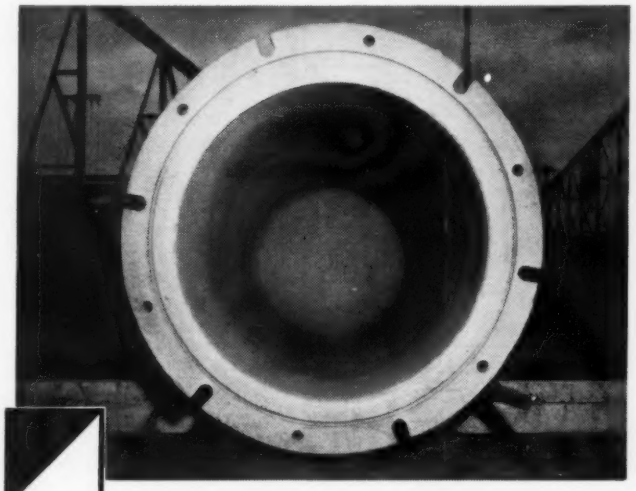
CLEVELAND TRAMRAIL DIVISION • THE CLEVELAND CRANE & ENGINEERING CO. • 5035 E. 290 ST. • WICKLIFFE, OHIO



23" Diam. Copper Crucible for Vacuum-Melting of Steel, completely fabricated and machined, ready for installation.



Copper Mold with Water-Circulating Ribs.



Copper Mold for Melting Titanium.

Welding Copper Ribs on Heads for Copper Crucibles.

VACUUM MELTING CRUCIBLES BY WELDCO

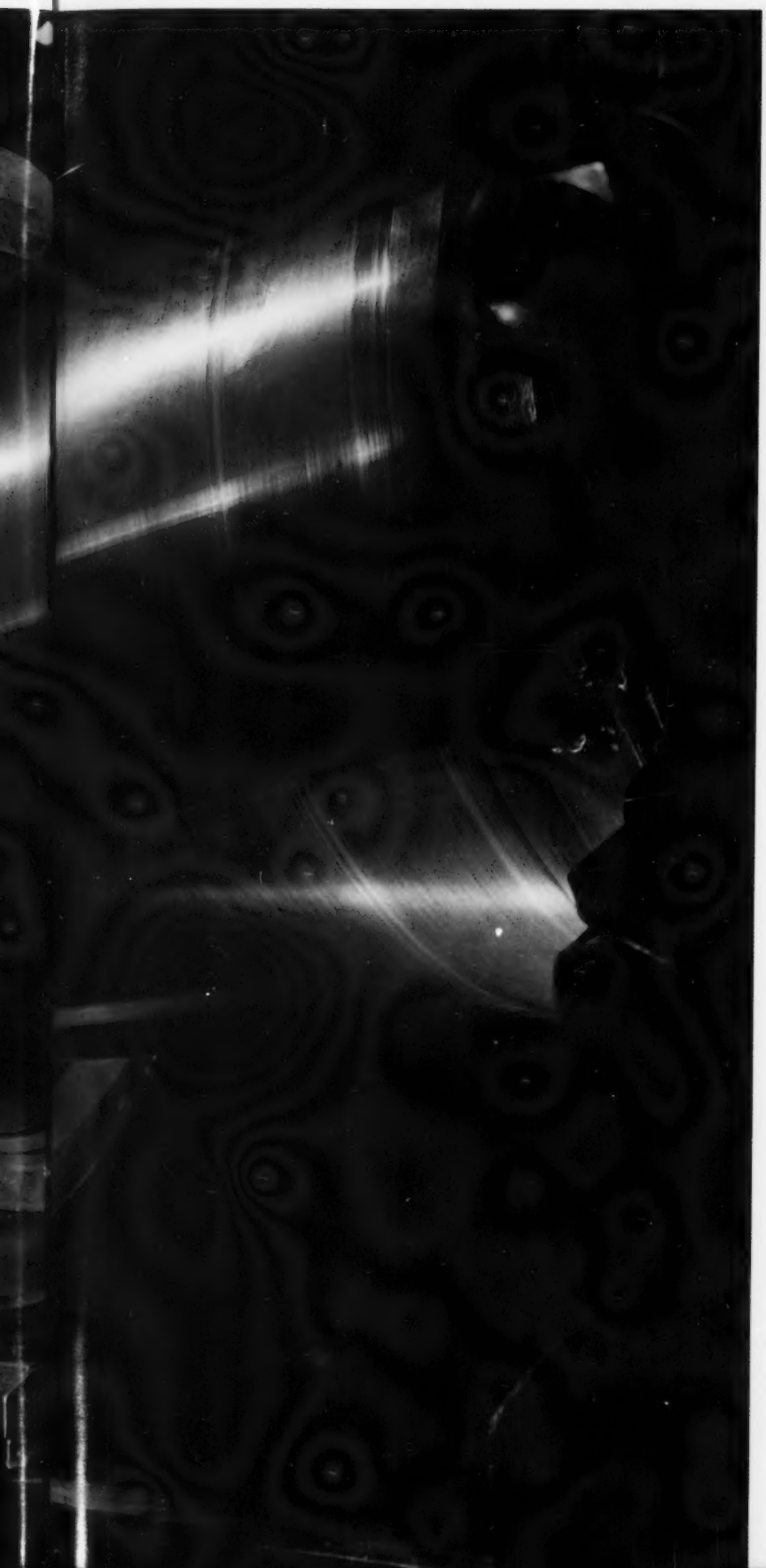
FOR TITANIUM AND ALLOY STEELS

We have had extensive experience in making Copper Molds, Jackets, and Furnaces for Vacuum-Melting of Alloys. Progressive producers are boosting their quality sharply by using the Vacuum-Melting Process. Why not investigate the possibilities?

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY
3805 OAKWOOD AVENUE . . . YOUNGSTOWN 9, OHIO

Down go back-up roll costs with

h USS Quality Forged Sleeves



PICTURED ABOVE is James S. Rennick, a metallurgist with twenty years' experience in the Forgings Division of U. S. Steel. Jim specifies composition, heat treatment, and other processing procedures essential to the production of assemblies as shown in the main picture—a back-up roll that will be used in the cold reduction tin mill at U. S. Steel's Gary, Indiana plant.

This job points up a curious situation: U. S. Steel is one of the country's leading manufacturers of rolls, and also one of the biggest *users* of rolls . . . a double reason to perfect their performance and reduce their cost . . . just as we did here.

We had to replace a worn, cast steel back-up roll. Rather than replace the entire roll, we machined the face of the roll and shrunk on a *forged* steel sleeve. For back-up rolls like this one, 42″ O.D. and larger, this method of sleeving is much less expensive than buying a complete new roll. One arbor can be used for several forged sleeves. A forged sleeve has a hard, wear-resistant surface and is highly resistant to spalling.

Also, the sleeve is purposely produced with a softer bore to develop a desirable stress pattern, and to provide maximum gripping between the arbor and sleeve after assembly.

There is a good possibility that we can help reduce *your* roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

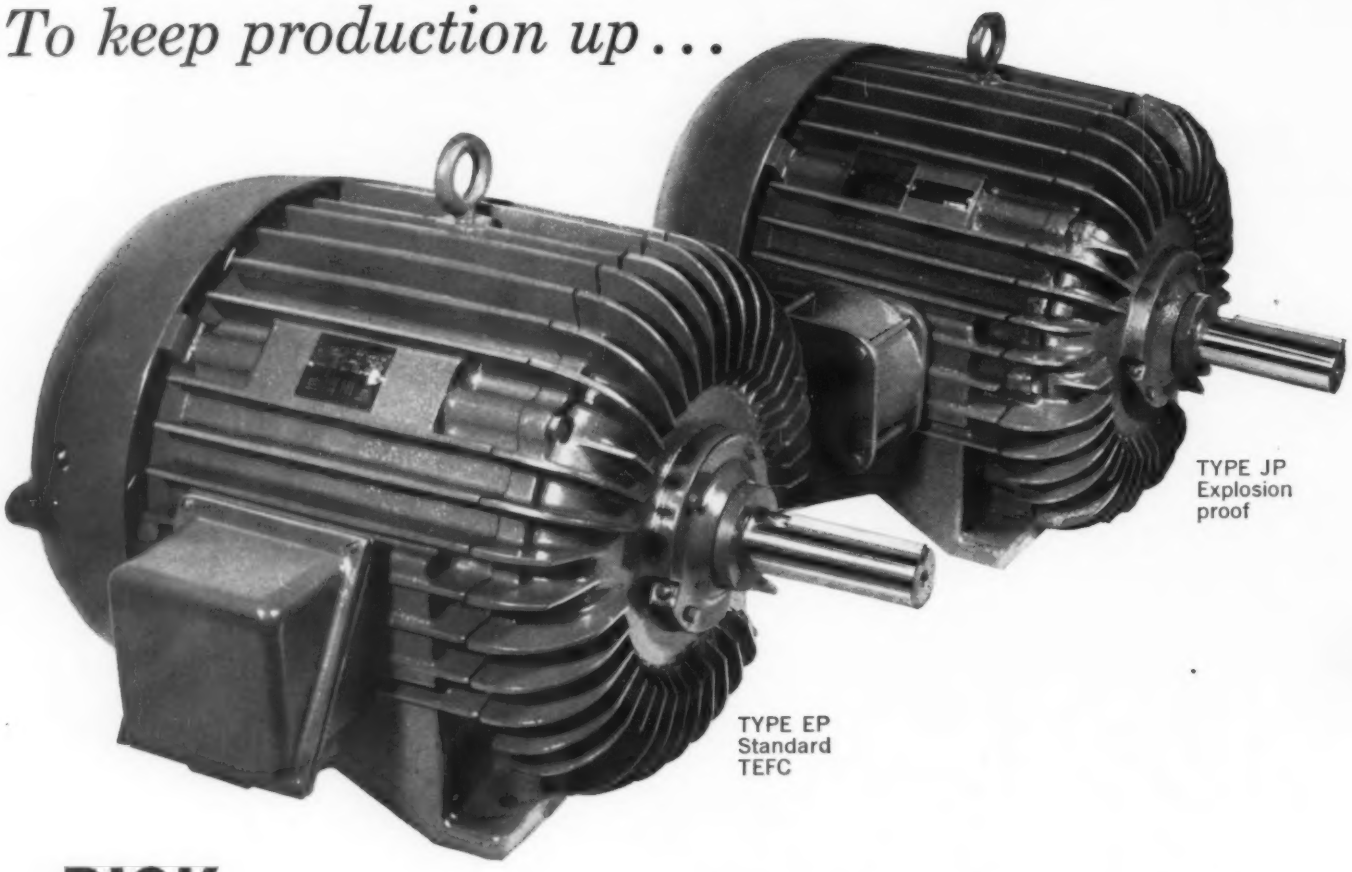
USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

USS

To keep production up...



TYPE JP
Explosion
proof

TYPE EP
Standard
TEFC

PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

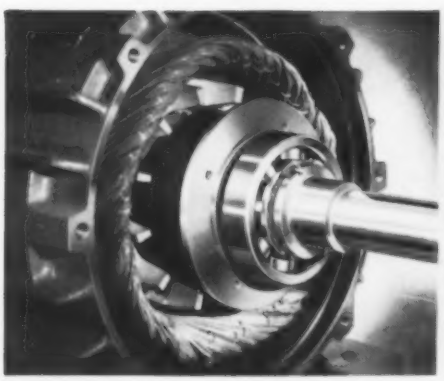
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

Wagner Electric Corporation

6483 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WM60-19



HEAVY-DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.

BEARINGS CAN BE RELUBRICATED . . . Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SECURELY SEALED FOR LOW MAINTENANCE . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Secret of long copper life

. . . PB & B high conductivity plus PB & B design

Tuyeres, bosh plates, roof coolers and oxygen jet heads from Philadelphia Bronze & Brass last longer . . . for two reasons that are important to every steel mill man.

HIGHEST CONDUCTIVITY COPPER. Records of actual steel mill service prove that high conductivity copper pays off in most days of service, highest production per dollar of copper investment. Our castings are made of virgin electrolytic copper, certified at 90% IACS minimum conductivity. Our forgings use OFHC* copper, guaranteed at least 98% IACS conductivity.

**Registered Trade Mark—American Metal Climax, Inc.*

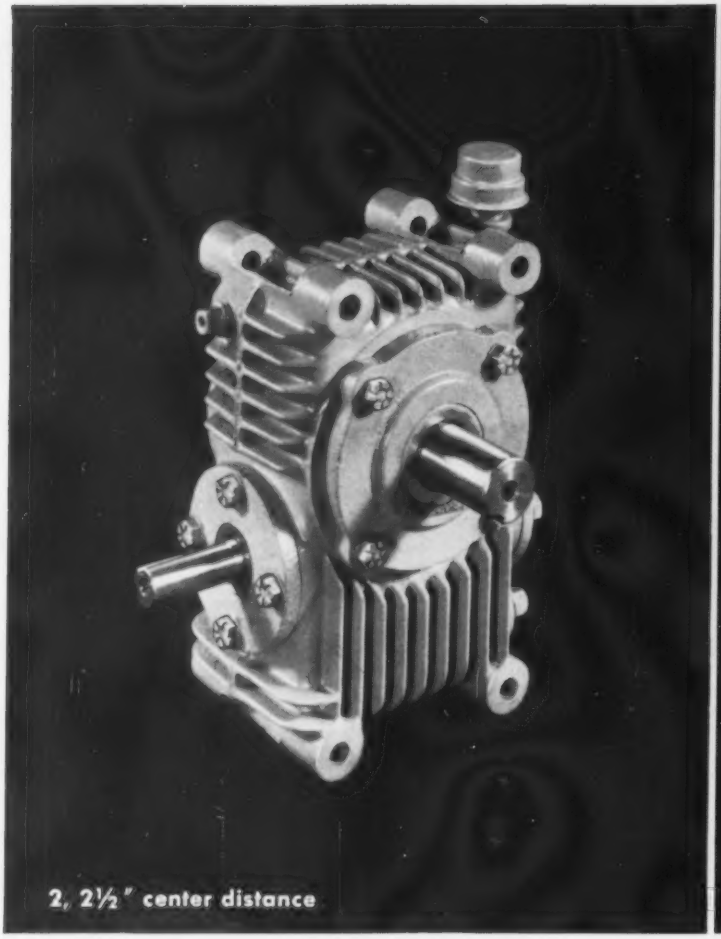
UNIQUE DESIGNS supplied by PB&B get the most out of high conductivity copper, provide maximum heat transfer, top economy of copper usage. Hoffman bosh and stack plates, for example, have dual cooling chambers which can be operated together or independently. Many PB&B copper components feature copper tubing cast in place in copper casting,** by exclusive PB&B methods, to gain highest cooling efficiency.

Write today for data on PB&B furnace copper, and for a proposal for your specific mill's requirements.

***Patent applied for.*

PHILADELPHIA BRONZE & BRASS CORP.
22nd and Master Streets, Philadelphia 21, Pa.

Furnace Products Division
a subsidiary of
P.R. MALLORY & CO. Inc.
MALLORY



2, 2½" center distance

3, 3½" center distance

Custom-build Your Worm Gear Drive from . . .

OVER 200,000 STOCK

The four "worm-under" speed reducers shown above represent only eleven sizes of standard, Cone-Drive units. Also standard are 15", 18", 22", and 24" center distance units. Cone-Drive worm gear reducers are available in ratios from 5:1 to 4900:1 and up to over 1200 HP capacity. All units feature the double-enveloping principle in which the worm and gear wrap around each other for greatest tooth contact, strength, smoothness, shock-resistance and quietness of operation.

All Cone-Drive worm-gear reducers feature heavy, ribbed, nickel-iron castings for maximum strength and heat dissipation. Heavy-duty taper roller bearings provide anti-friction support to both worm and gear shafts. Chrome-molybdenum-nickel steel worms and tin bronze gears provide long life and high strength. The Cone-Drive design also gives the exclusive benefit that, in service, both gear and worm tend to regenerate their true form . . . worm and gear wear "in" rather than "out."

Standard Options

By selecting various options, standard units can be obtained to fit almost any drive requirements. By taking advantage of these options in the early design stages, you can often simplify design and improve performance, too. Including size and ratio ranges and options available, Cone-Drive Gears offers over 200,000 worm-gear speed reducer combinations that are standard, shelf-hardware items. Special sizes and ratios can be furnished on a quotation basis. Write for Bulletin CD-218 for complete details.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

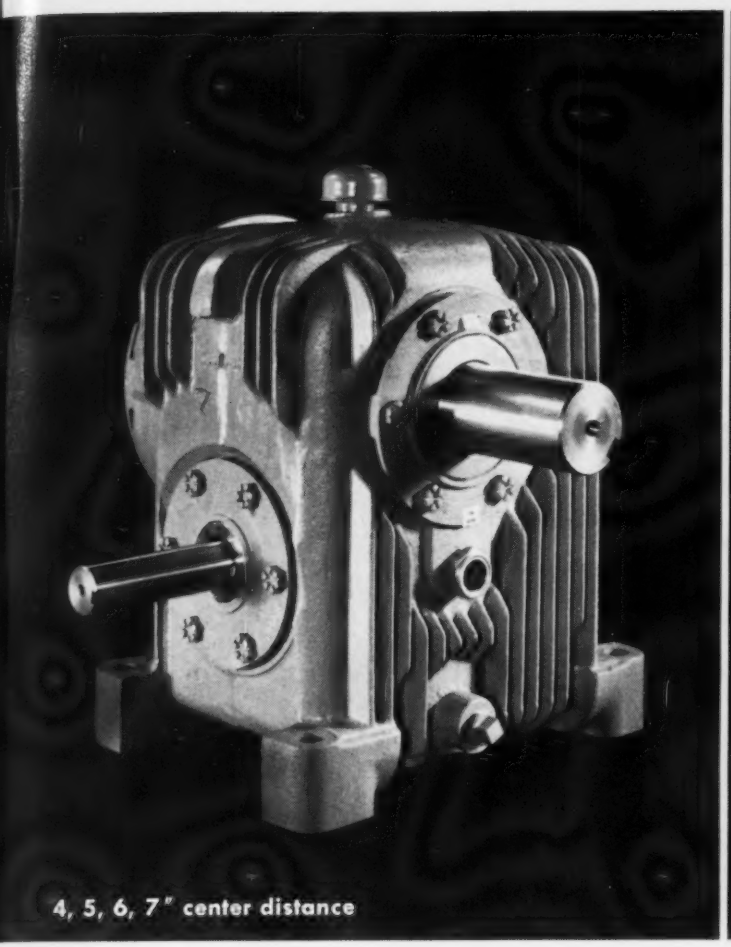
7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

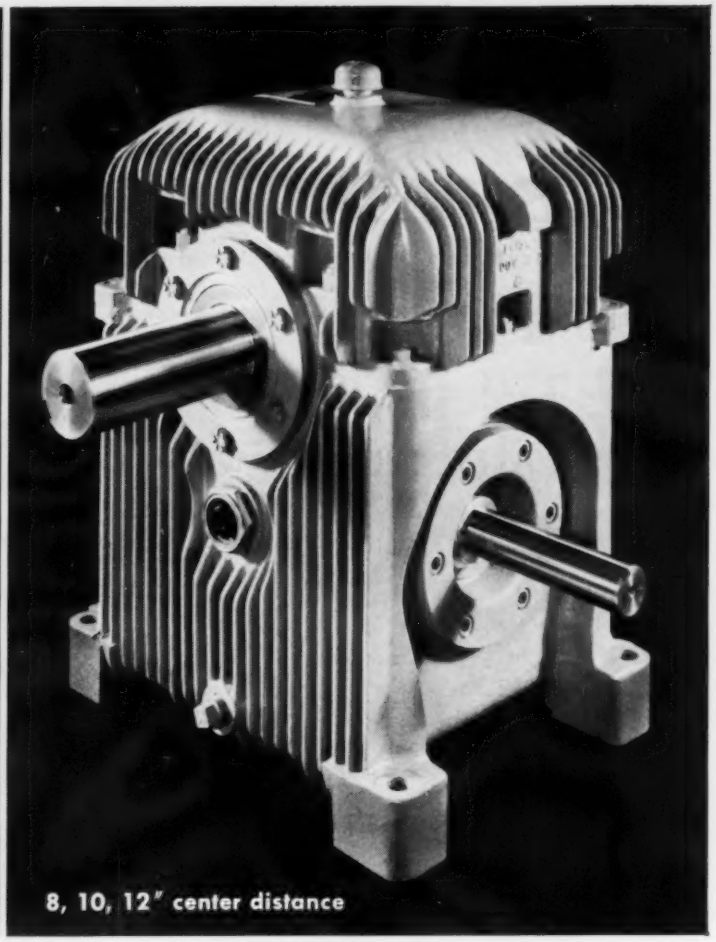
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



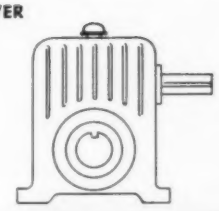
4, 5, 6, 7″ center distance



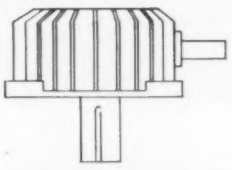
8, 10, 12″ center distance

CONE-DRIVE REDUCERS

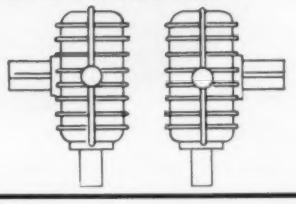
WORM-OVER



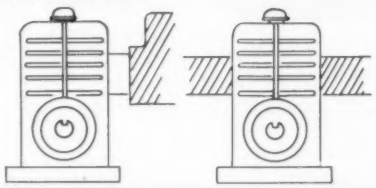
VERTICAL GEARSHAFT



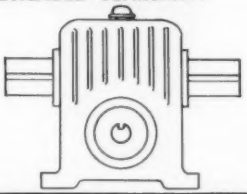
RIGHT- OR LEFT-HAND SHAFT



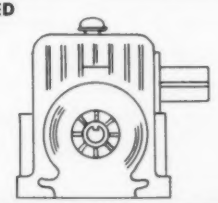
SHAFT MOUNTED



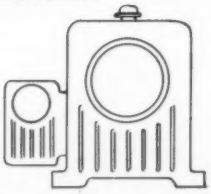
DOUBLE-EXTENDED GEARSHAFT



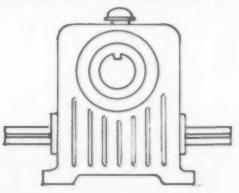
FAN-COOLED



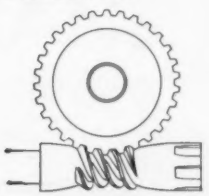
DOUBLE REDUCTION



DOUBLE-EXTENDED WORM SHAFT



GEARSETS & MOUNTINGS

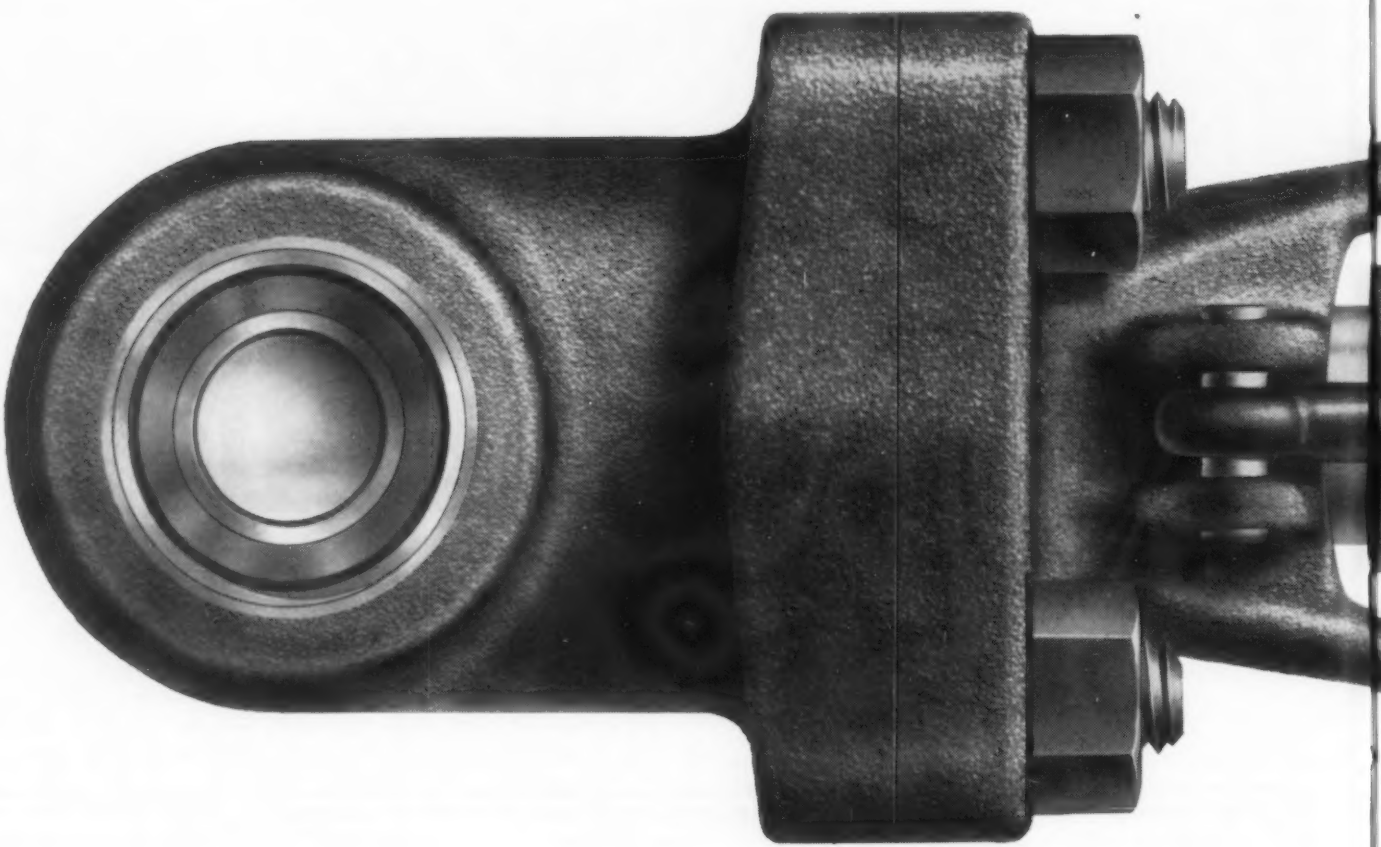


Reporting more news from . . .

CRANE DIRECTION '70

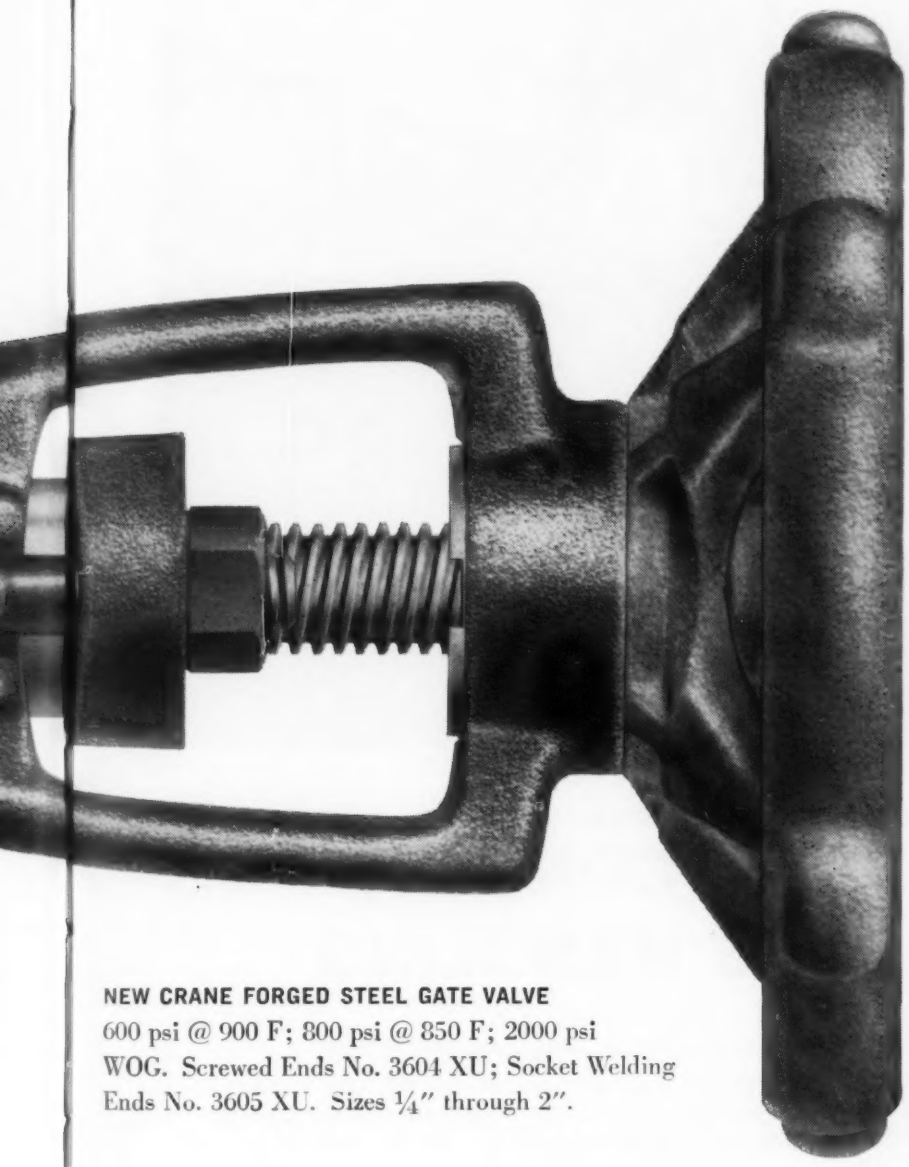
. . . a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the competitive challenges of the Sixties.

COMPLETELY



REDESIGNED!

THE NEW SMALL FORGED STEEL GATE VALVE



NEW CRANE FORGED STEEL GATE VALVE
600 psi @ 900 F; 800 psi @ 850 F; 2000 psi WOG. Screwed Ends No. 3604 XU; Socket Welding Ends No. 3605 XU. Sizes ¼" through 2".

This is a whole new valve, not just one with a new feature added. This redesign incorporates all the features you told us you wanted plus a few others we know will make this valve a better buy in terms of longer service life, less maintenance, easier and faster servicing.

Like the new "bow-leg" yoke, which for the first time gives you plenty of hand room for easy stuffing box maintenance. And like the long-life braided asbestos packing, with Inconel wire insert. The "universal" trim that can be used for either oil or steam, eliminating many of your stocking problems. The spiral wound stainless steel bonnet gasket with asbestos filler, made blowout-proof with a male-female joint.

But what we really want you to remember, more than any single feature, is that this Crane valve is the newest—all new—valve on the market . . . well worth considering when you need small, high-pressure steel gate valves. We'd like you to compare this new valve with any other comparable valve feature for feature.

Your local Crane distributor has technical literature and a complete selection of these valves right in stock. Call him on small steel gates. In fact, he's your best bet to call no matter what valve you want because he carries the broadest line of quality valves in the world.

CRANE®

CRANE CO., INDUSTRIAL PRODUCTS GROUP
4100 S. KEDZIE AVE. • CHICAGO 32, ILL.
VALVES • ELECTRONIC CONTROLS • PIPING
PLUMBING • HEATING • AIR CONDITIONING

In a delivery to the U.S. Steel Gary works, the temperature of the grease was 25°F. Still, 22,860 lbs. of grease were pumped to the storage tanks in 65 minutes, with a pressure of 100 psi.

Cities Service Announces

REVOLUTIONARY CONCEPT IN BULK GREASE HANDLING

Until now the standard container for shipping and handling industrial greases has been the 400 lb. drum. For companies using large quantities of grease, these drums present such problems as: cost of storage and multiple handling—full and empty; up to 10% residuary waste; and the necessary cost of the drums themselves.

Cities Service, in cooperation with DuBois Engineering and Manufacturing Corp., recently embarked upon a program to develop a system for delivering grease in bulk from "the grease kettle to the bearing." The result is a tractor-trailer unit with two 12,000 lb. capacity containers. A gear-type pump on the truck transfers the entire load to the customer's stationary central storage containers in less than an hour. This system revolutionizes the concept of grease handling for companies using centralized systems.

The new Cities Service bulk-delivery truck is presently operating in the mid-west states with plans for expanding this service to other areas.

If you are a bulk grease user, the time and money this system can save you are well worth looking into. For the full story, call your local Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, 20 N. Wacker Drive, Chicago 6, Ill.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"COOLING WITH ORE (INSTEAD OF SCRAP) IN THE OXYGEN TOP BLOWING LD PROCESS"

by K. GRUNBERG, W. SCHLEICHER, and R. KUNZ, Bochumer Verein fur Gusstahlfabrikation A.G., Bochum, Germany. (Translation No. 4800 from Stahl und Eisen, vol. 80, 1960, No. 5, pp. 277–281)

BOCHUMER Verein, Ruhr, Germany has erected an LD steelmaking plant that was put into operation November 2, 1957, replacing a dismantled pig and ore process open-hearth plant with prerefining mixers. In view of the favorable results that had been obtained with the pig and ore process, in producing steel low in residuals, it seemed logical to use iron ore for cooling in the oxygen process, rather than the customary steel scrap.

The amount of steel produced by this process up to the beginning of July, 1958, was 180,000 tons. During .the early months, emphasis was on mild unkilled and killed steels. After the teething troubles had been overcome, considerably more attention was given to the harder types; production then was 30 per cent higher-carbon steel, 40 per cent mild killed steels and 30 per cent mild rimmed steel.

The advantages of ore cooling are the following:

1. A rather high degree of freedom of the steel from undesirable companion elements.

2. The rolling mill scrap is all virgin scrap and highly suitable for the production of high-grade steels in the open-hearth and arc furnace.

3. The life of a 35-ton LD furnace lined with green tar-bonded dolomite brick is longer than with scrap cooling, the average being 300 and the maximum 346 blows. The taphole or spout life is equally long. The ladle lining lasts 50 blows on the average.

4. Depending on the prices of pig iron and scrap, ore cooling may be cheaper. At the end of 1957 and the beginning of 1958, it resulted in a savings of 3 DM (U.S. $0.75) per metric ton of steel.

5. By adding the ore through overhead charging chutes, the time used for scrap charging is saved; this amounts to about 10 per cent of the total heat time.

6. The metallurgical oxygen consumption with the production program given above is 50 cu meters per metric ton (1600 cu ft per net ton) produced; for mild steel alone, 48 cu meters per metric ton (1550 cu ft per net ton). These amounts are respectively 12 and 15 per cent less than when scrap is used as coolant.

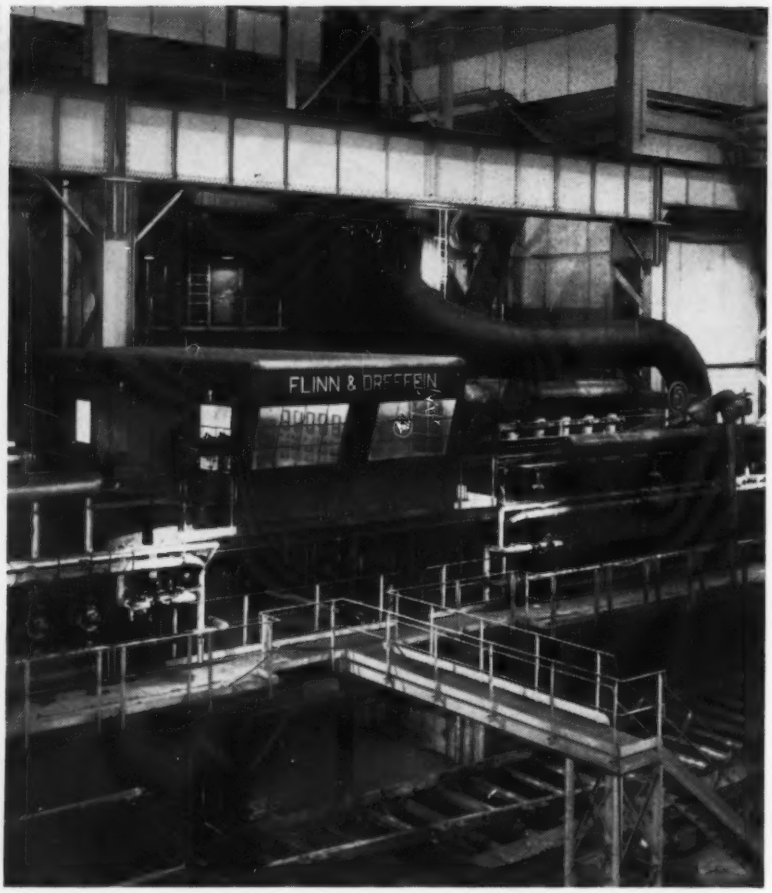
After the melting operation was running smoothly with ore cooling, metallurgical studies were initiated to determine the carbon, etc., drop and slag composition curves for the process. These show that ore as a coolant in the LD process does not, as has been generally assumed, unduly raise the oxygen content of the bath throughout the entire blow, but that the oxygen introduced with the ore is used up during the first eight minutes at the latest.

The oxygen, nitrogen and hydrogen contents were also determined and compared with those of open-hearth steel. On the basis of these results, it is shown that LD steel produced with ore cooling, because of its relative freedom from undesired elements and its low hydrogen and nitrogen contents, is superior to open-hearth steel for certain applications; and it is at least equal to LD steel made with scrap as a coolant.

OTHER AVAILABLE TRANSLATIONS

"Appraisal of Behavior of Ores and Sinters in Blast Furnace," by P. Dickens, W. v.d. Esche, and J. Willems. Stahl Und Eisen, vol. 79, 1959, No. 13. Need of blast-furnace operator for more information on the prospective behavior of ores and sinters in smelting to select the most appropriate burden for efficient reduction. Authors' study of mechanical stability of ores and sinters and their softening under load at high temperatures in a reducing atmosphere. Use of the refractoriness - under - load test (hitherto reserved to refractories) for cube and cylinder-shaped specimens. Determination of softening, fusion, and flow points in hot-stage microscope. Comparison of results of the two methods; which method is preferable for sinters? Reduction experiments in gas stream with city gas according to L. Mathesius; and with a 65 per cent N+35 per cent CO mixture. New experimental arrangement with continuous recording of gas composition. Reduction curves for Venezuela and Swedish ores; effect of variation of gasflow rate. Microscopic study of ore reduction in hot-stage microscope: structural makeup of the several ores in their initial state and after reduction. Proposal for an ore data card index file as a valuable aid to the blast furnace operator. (Translation No. 4662)

Panel features Speedomax H Electro-pneumatic Controllers.



Reheating furnaces and control pulpit at South Works.

New reheat furnaces have Speedomax® H control

Direct bloom-temperature measurement guides control settings

300 tons per hour of correctly heated blooms and slabs . . . that's the combined rated capacity of two new Flinn and Dreffein reheat furnaces at U. S. Steel Corporation's South Works.

The two furnaces, believed to be the largest in the United States, are essential to U. S. Steel's expanding structural-shape capacity. And essential also to this expansion is the assurance that blooms and slabs are thoroughly heated to the correct temperature, keeping rolling mills on schedule.

U. S. Steel operators now have that assurance, with 10 zones of modern Speedomax H Electro-pneumatic control providing smooth regulation of fuel valve settings . . . keeping each zone "dead-on" optimum temperature.

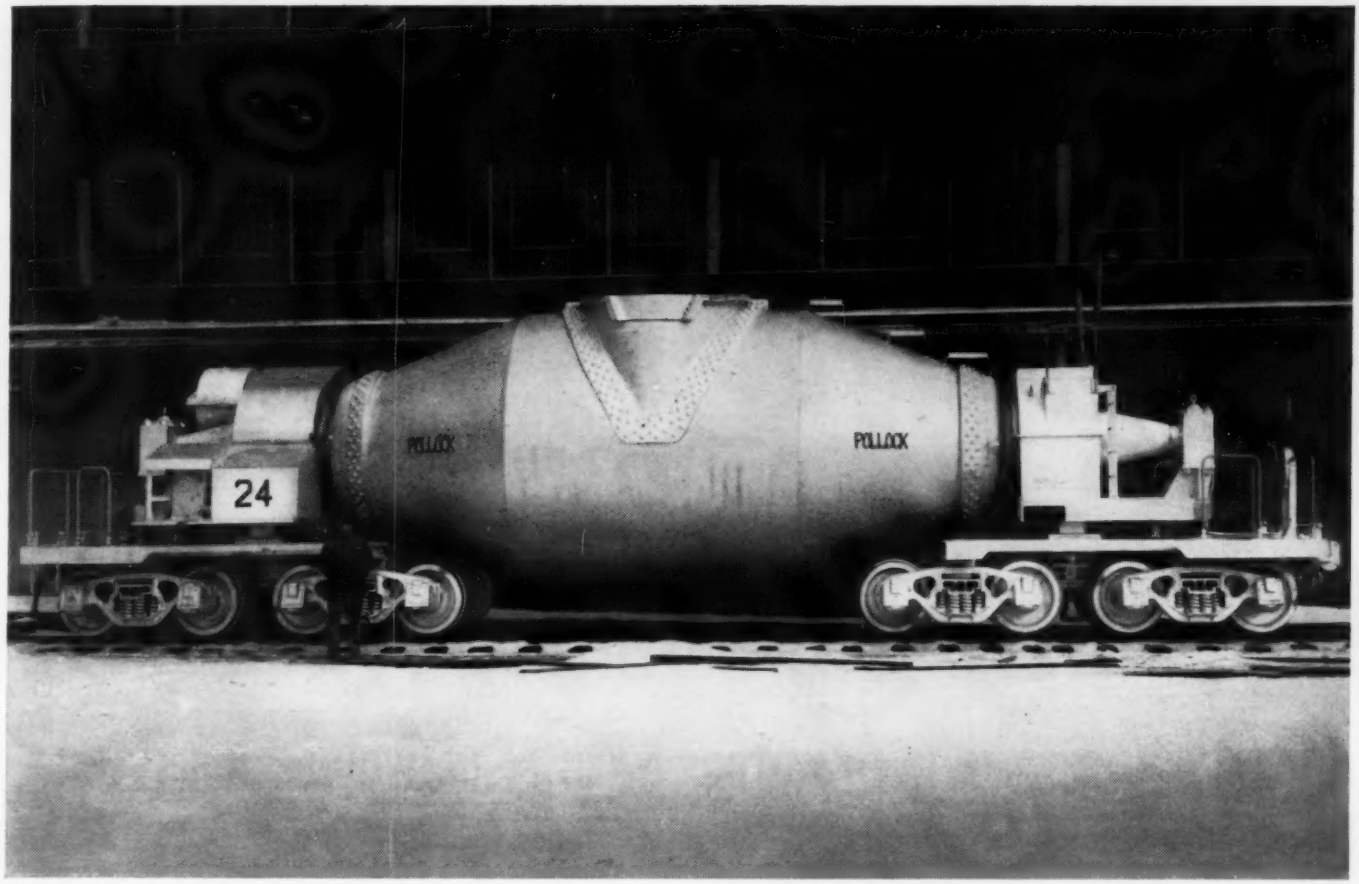
And to help assure that the blooms are "on temperature" as they leave the furnaces, an L&N Rayotube heat-radiation detector will sight directly on the surface of the bloom after the first pass through the mill. Should recorded temperature at this point deviate from the optimum value, zone-temperature set-points in the final furnace zones are corrected to provide maximum production.

Leeds and Northrup, U. S. Steel and Flinn and Dreffein worked closely together to produce this modern control system. Let L&N work with you, too, in the design of a control system that will correctly solve your production problems. Call your nearby L&N office, or write 4942 Stenton Avenue, Phila. 44, Pa.

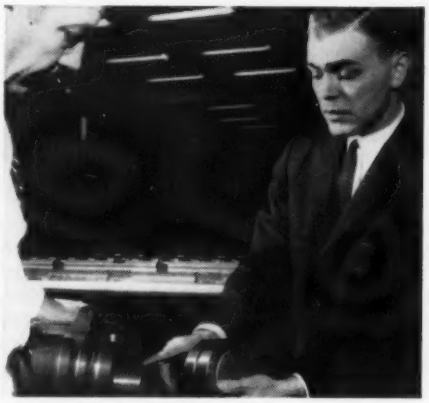
LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

Pioneers in Precision

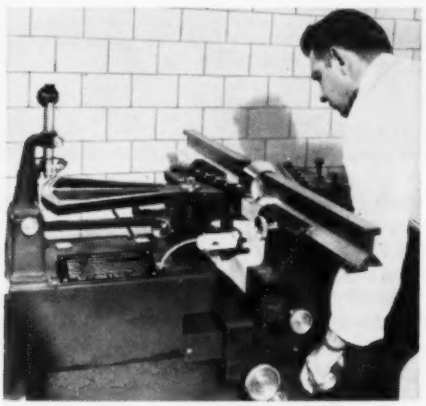
Hot car rolls on cool bearings—



Weighing a whopping total of 360 tons, this car transports 200 tons of hot metal from blast furnace to refining unit. To be sure of cool running wheel bearings to make the car roll easier, take the terrific loads and shock impact, the car manufacturer—The William B. Pollock Co.—specified Timken® heavy duty "All Purpose" tapered roller bearings, the type used on more and more of America's freight cars. Because Timken bearings *roll* the load they practically eliminate friction. Cars start and roll easier, saving power. And because of their tapered design Timken bearings take *both* radial and thrust loads. No auxiliary thrust collars are needed. Timken "AP" bearings come pre-assembled, pre-lubricated, ready to install. They will go 4 years without adding lubricant. Maintenance is reduced, car availability increased. What's more, they cut locomotive wheel spinning, decrease wheel wear, eliminate flat spots on rails and increase rail life.



YOUR SAVINGS MOUNT when you use the services of our graduate engineer salesmen. They'll work with you at the design stage, can often solve your bearing problems *on the spot.*



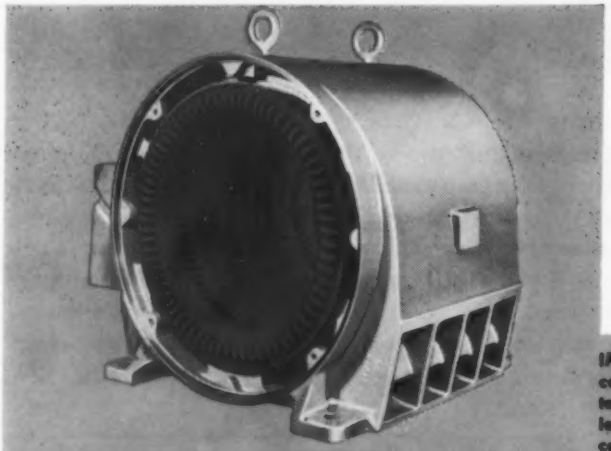
GREATER BEARING ACCURACY is assured through super-sensitive gages in our master gage laboratory, one of industry's finest. Some instruments measure even the thickness of a molecule.

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.

UNEXCELLED PROTECTION

for vulnerable motor coils

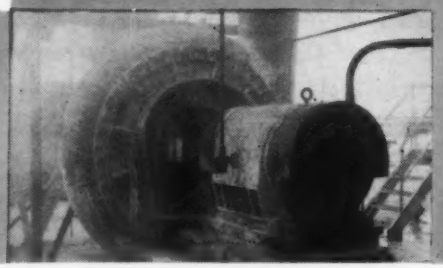
FOR INTEGRAL H. P. MOTORS WITH FORM-WOUND COILS



WOUND STATOR—Core and frame are dipped in EPA-SEAL epoxy resin and baked before winding. Slot coils are epoxy-glass, and all connections are taped with epoxy-mica and glass tape. After winding, the entire stator is given the EPA-SEAL vacuum-pressure process described below.

IMPREGNATED COIL—Finished coil is entirely covered with glass tape before impregnation. Where leads leave the coil, special epoxy compound seals against entrance of moisture. The entire slot section is protected by epoxy-mica wrapper.

NOW OPERATING. One of the first epoxy-insulated, form-wound motors in service was the 350 hp Epa-Seal motor shown below. It operates under severe corrosive atmospheric conditions, plus constant spray from nearby cooling tower.



The Elliott EPA-SEAL epoxy insulation system for integral hp motors includes the application of epoxy resins to all vulnerable parts, and a unique process of vacuum preconditioning and pressure impregnation. Vacuum preconditioning is accomplished by placing wound stators in a tank which is sealed and evacuated. This removes all air and moisture from within the coils and coil slots.

Then while still under vacuum, impregnation is accomplished by pumping special epoxy resin into the sealed tank under pressure. The combined vacuum and pressure treatment assures deep penetration of the resin into the innermost spaces of the coils and coil slots. The result is a tough, impervious, resilient, void-free protection against salt water, acids, alkalis, solvents, cutting oils, carbon-black, abrasives. This exclusive Elliott C-W insulation withstands heat, cold, vibration, resists chipping and cracking, takes cold shock and thermal cycling unharmed. EPA-SEAL epoxy-insulated motor stators with form-wound coils have been completely submerged in water for three months without impairment of insulation resistance or dielectric strength.

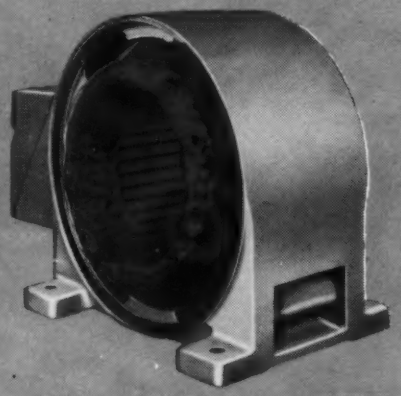
WO-1

Elliott's tough, resilient

EPA-SEAL

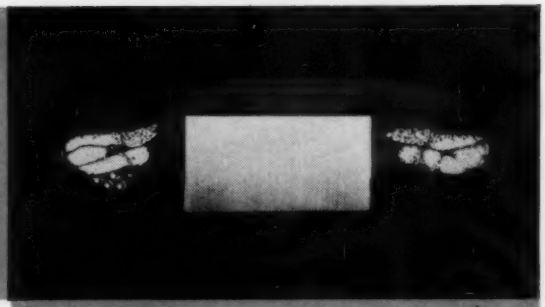
epoxy insulation system

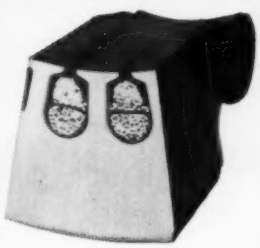
FOR INTEGRAL H. P. MOTORS WITH RANDOM-WOUND COILS



ENCAPSULATED STATOR—Entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. Epoxy resin fills slots completely, penetrates coils. Protects laminations, too.

Note in sectioned stator core below how EPA-SEAL completely fills the slots. All conductors are completely encased by this unique epoxy insulation system.





NO VOIDS—Vacuum preconditioning and pressure impregnation assure void-free insulation. Phase insulation is entrapped in the epoxy resin, which even penetrates into lead sleeving. Note how EPA-SEAL bonds to the stator core, seals against moisture. Relatively thin build-up over coils permits rapid dissipation of heat from conductors.

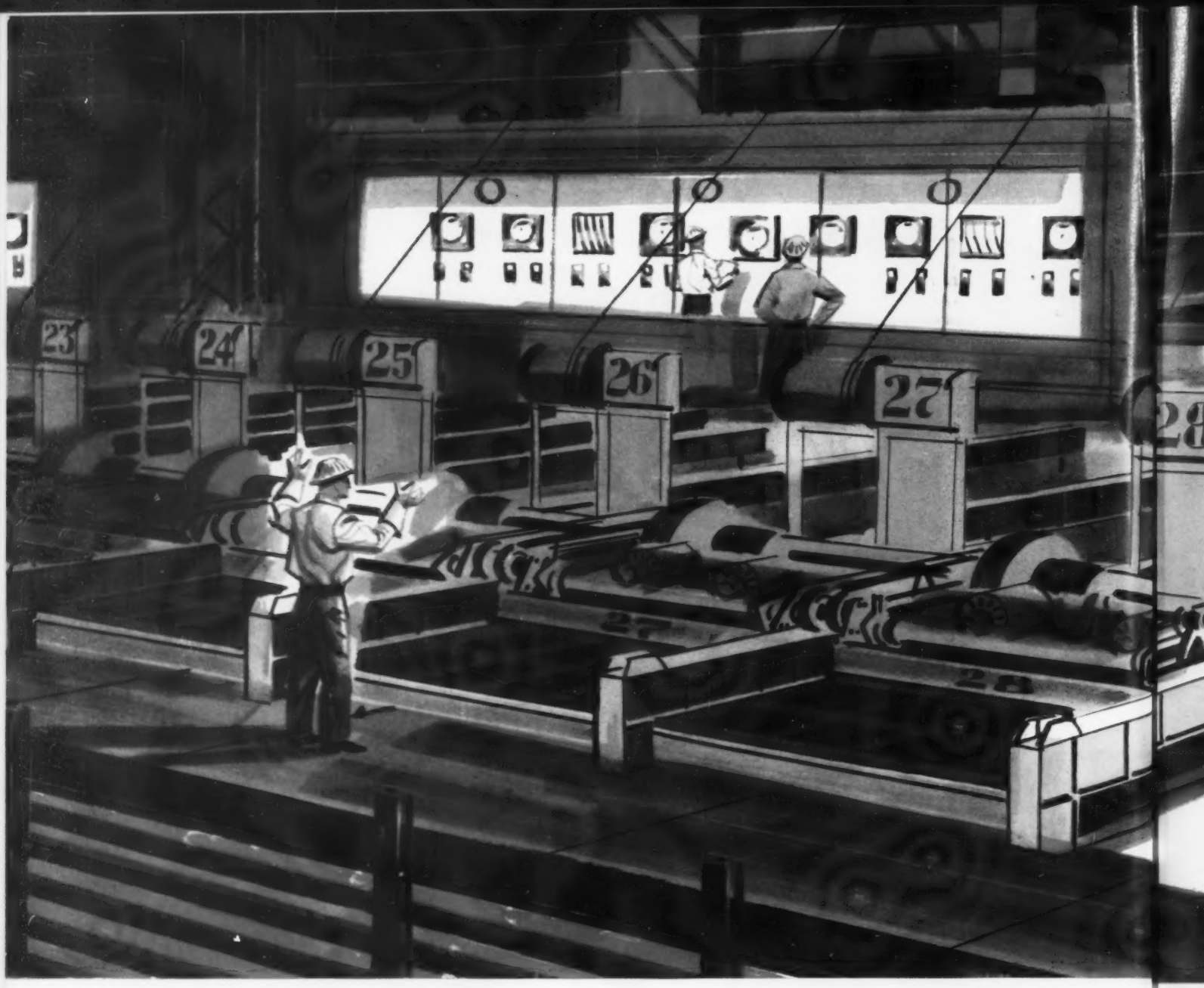
For motors with random-wound coils, the method customarily used for encapsulating consists of applying an external coating over exposed coil ends. But with the Elliott EPA-SEAL system, the entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. In addition, stator and rotor laminations are treated with a special anti-corrosive epoxy coating. All hardware is protected by a corrosion-resistant treatment. Weatherproof conduit boxes are standard. Motors are adaptable to NEMA Type I weather protection. Epa-Seal random-wound motors have run while completely submerged in water for more than 1000 hours, without failure.

Elliott Epa-Seal motors are ideally suited for service in chemical and petrochemical plants, paper mills, rubber mills, in deep mines or coastal service—wherever moisture or corrosive atmospheres demand superior motor insulation.

WRITE FOR **New Bulletin PB 6000-12, giving further details on the remarkable EPA-SEAL insulation system. Crocker-Wheeler Plant, Elliott Company, Jeannette, Pa.**

ELLIOTT Company

CROCKER-WHEELER PLANT • JEANNETTE, PA.

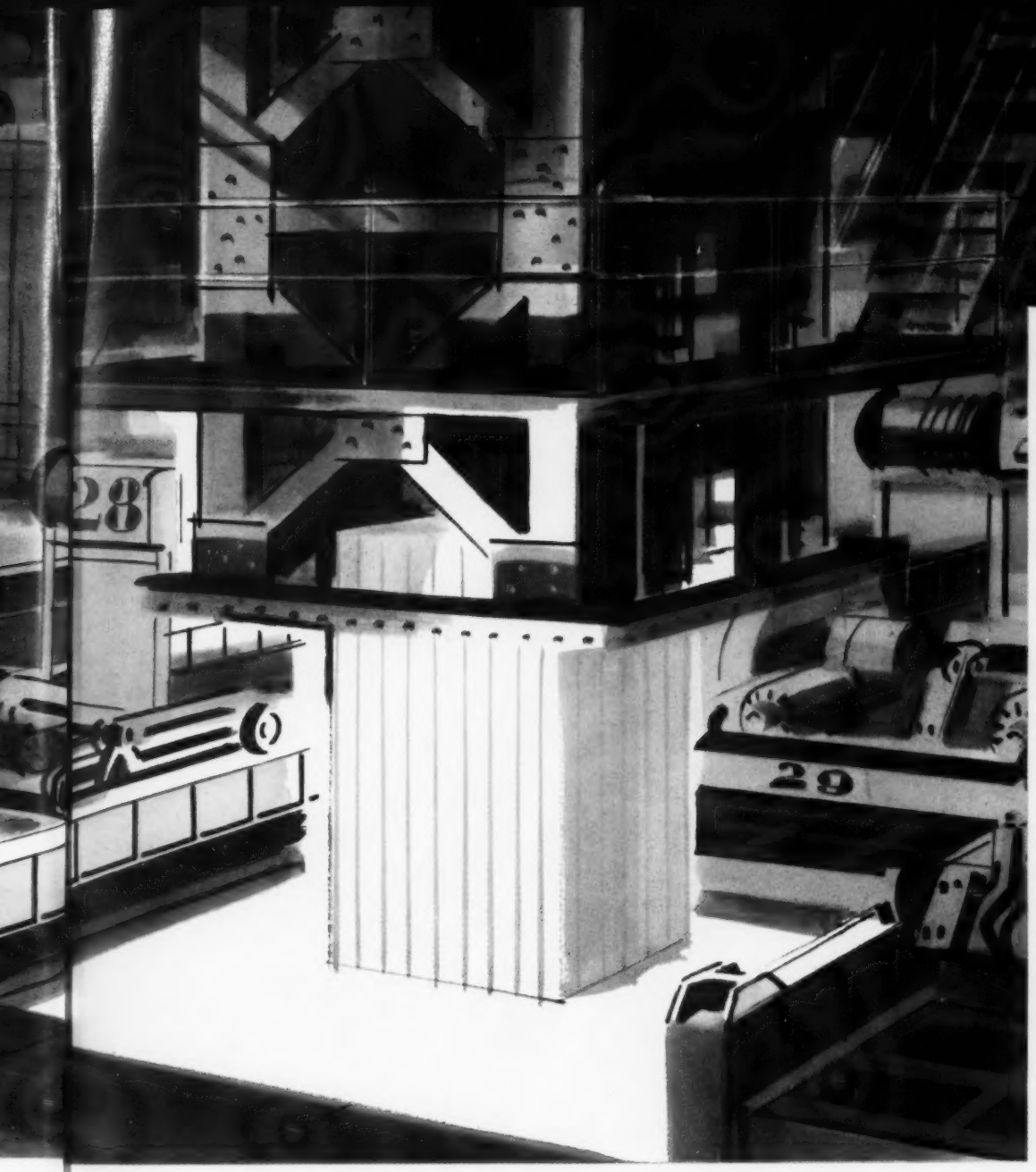


From Republic Flow Meters . . .

Complete electronic control

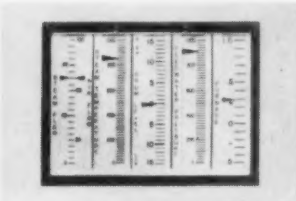
When you specify Republic Flow Meters engineering service in the designing, building and installing of electronic control systems for soaking pits, you benefit from the experience of a leading furnace control manufacturer. The complete line of Republic pneumatic and electronic equipment handles the metering, recording, indicating, and controlling of soaking pit operations for both recuperative and regenerative type furnaces. Republic controls are performing daily on soaking pit operations, handling the fuel-air ratio control, flue draft control, air and gas pressure control, air flow recording, etc.

When you install new soaking pits, or overhaul existing ones, check the important advantages you get from Republic Flow Meters Complete Control Engineering Service:



Complete electronic control systems are available for controlling the various functions in soaking pit.

Republic Flow & Pressure Recorders register electrically, pneumatically or mechanically, are simple, compact.

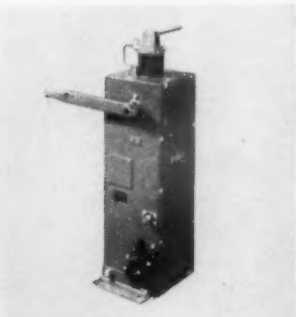


Republic V-5 Gauges for draft, pressure, flow temperature and differential pressures, have 5" vertical scales.

for your soaking pits

1. **Single-source service, and responsibility for controls system**
2. **Depth of engineering experience in building pneumatic and electronic control systems for over forty years**
3. **Nation-wide network of experienced field engineers, installation supervision, and final system adjustment**

For information, contact the Republic Representative nearest you, or write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Ill. In Canada: Republic Flow Meters Canada, Ltd., Toronto. Subsidiary of Rockwell Manufacturing Company.



Republic Final Drive Units operate valves, damper, inlet vanes, etc., in response to air loading pressures or electronic signals.

REPUBLIC INSTRUMENTS AND CONTROLS

more fine products by

ROCKWELL

This Heroult Electric Furnace does the most efficient steel melting job at Lukens Steel

Two years ago, Lukens Steel Company installed this 20-foot diameter Heroult in their Coatesville Plant. It's a standard Heroult top-charge, swing-roof furnace with a nominal capacity rating of 100 tons. In almost continuous operation since installation, producing ordinary carbon and low-alloy steels, the Heroult's performance has proved the matchless efficiency of electric melting.

The Heroult is 100% mechanically operated. All movements are motor-driven gear mechanisms. This reduces maintenance problems, and permits your own maintenance crew to keep it performing with a minimum of effort. The Heroult has other features such as cage-type shell construction, independently supported operating mechanism, and water-cooled skewback roof ring. They all help to make the Heroult the finest electric melting furnace available.

Heroult Electric Arc Furnaces are available in shell diameter sizes from 7'0" up, and with a rated charge capacity from 4 tons to over 200 tons. You can select door-charge or top-charge swing roof type. We'll also furnish special induction stirring equipment, duplexing arrangements, and furnaces for melting of copper and nickel.

American Bridge has the facilities and the technical know-how to handle a complete melt shop installation. This includes design, construction and installation of machinery. For complete information, get in touch with the contracting office nearest you. Or write to our Pittsburgh Office.

USS and Heroult are registered trademarks

American Bridge Division of United States Steel

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D-C CIRCUIT BREAKERS MADE IN 1928 ARE HOPELESSLY BEHIND THE TIMES

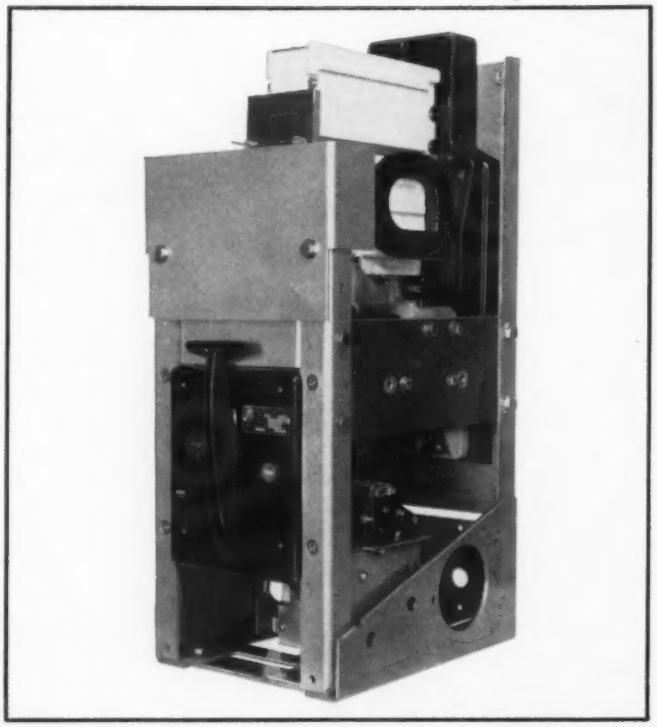
They're too slow. They can't handle the higher loads on your present circuits. They can be responsible for enormous damage to equipment in case of short circuits. And they are unsafe for personnel.

Actually there's no economy at all in trying to stretch out the life of 20 to 40-year-old d-c circuit breakers. Figure out just how much it will cost you to repair the damage to equipment alone when you have a severe overload or short circuit. Add the cost of machine downtime and you have a prohibitive expense. Probably for even less than the cost of one overload, you can install a new modern, high-speed I-T-E Model FB circuit breaker. And you will have the benefit of its superior performance for years.

The I-T-E Model FB breaker gives you current limiting action *within 6 milliseconds.* And it may be safely applied to 1000 volt d-c circuits having a rate of rise of 15 million amperes per second. Yet this high speed costs you no premium.

In addition, because the I-T-E Model FB breaker uses modern materials and techniques not available to designers of old breakers, it's much more compact and weighs many pounds less.

I-T-E Model FB d-c circuit breakers are available either 1 or 2-pole, and in capacities from 1200 through 12,000 amperes continuous. Write for Bulletin 4601-A. I-T-E Circuit Breaker Company, Dept. SW, 1900 Hamilton St., Philadelphia 30, Pa.



Model FB d-c circuit breaker, stationary single-pole, with manual stored energy closing.

I-T-E CIRCUIT BREAKER COMPANY

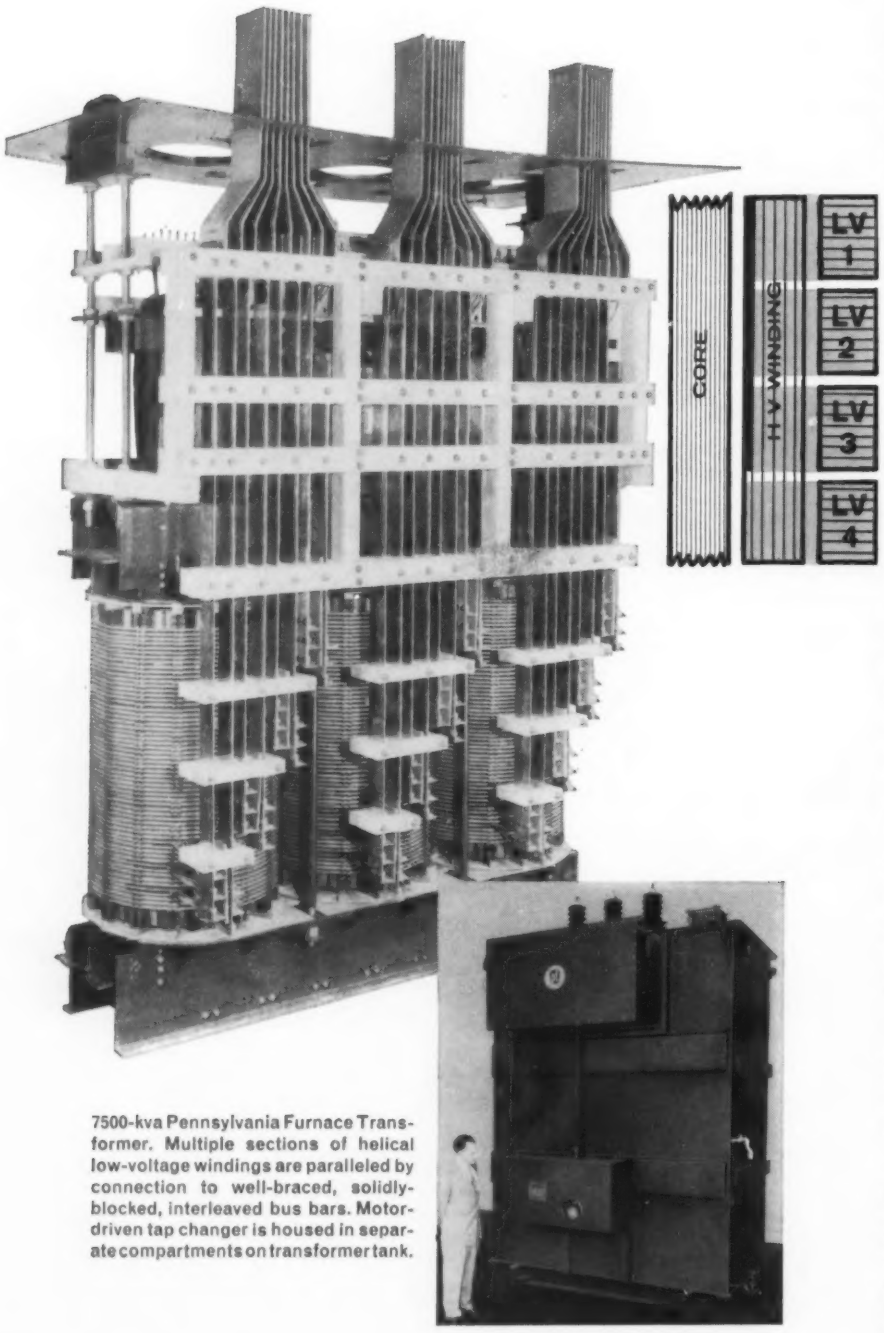
BLAW-KNOX

Blaw-Knox designs and builds all types of cold reduction and temper mills for ferrous and non-ferrous work. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company, Foundry and Mill Machinery Division, Blaw-Knox Building, Pittsburgh 22, Pa.

60-inch, 4-stand tandem cold reduction mill and temper mill

In a quarter-of-a-century...

there has never been a failure in the helical-type secondary winding of a Pennsylvania Furnace Transformer



7500-kva Pennsylvania Furnace Transformer. Multiple sections of helical low-voltage windings are paralleled by connection to well-braced, solidly-blocked, interleaved bus bars. Motor-driven tap changer is housed in separate compartments on transformer tank.

Since 1936, when Pennsylvania introduced a new type of helical winding for the low-voltage coils of furnace transformers, there has *never* been a low-voltage winding breakdown on any Pennsylvania Furnace Transformer using this design. Here are a few of the reasons:

1. Magnetic balance is established with a sectionalized low-voltage winding. As indicated by shaded areas in the accompanying sketch, this balance is maintained section-by-section even with portions of the layer-wound high voltage winding tapped out (black area), since no distortions are created in the magnetic pattern.

2. Internal forces are low as a result of the above method. To protect further against axial short-circuit forces, coils are hydraulically compressed with a force equal to the maximum short-circuit force that might occur in service. The circular shape of the coils prevents distortion from radial short-circuit forces. Coils receive a multiple treatment of thermo-setting adhesive which securely bonds the coils together. Then they are clamped and braced in the core frame so that no deformation or displacement can occur.

3. Current balance is maintained by progressively transposing the multiple low-voltage conductors in such a way that a complete transposition is made in each section, regardless of the number of turns or sections.

4. Bus bars of opposite polarity are interleaved to reduce reactance and improve current distribution. They are well braced to prevent deflection and incidental contact during short circuit.

* * *

Briefly, these are some of the factors that account for the outstanding trouble-free performance of Pennsylvania Furnace Transformers in gruelling day-in, day-out service. To take advantage of this service-proved reliability... please contact Pennsylvania Transformer Division, McGraw-Edison Company, Box 330, Canonsburg, Pa.

PENNSYLVANIA FURNACE TRANSFORMERS

. . . . an economic study by Lukens Steel Co. determined that the use of mercury arc rectifiers to power their 140-in. slabbing mill would result in substantial savings in installation, maintenance and power costs, plus the added advantage of a lower inventory of required spares . . . .

The Application of the Mercury Arc Rectifier to large reversing mill drives

by M. B. ANTRIM,
Manager,
Engineering and Construction Div.,
Lukens Steel Co.,
Coatesville, Pa.

THE use of the mercury arc rectifier to provide power for motors used in the metalworking industry is not new. As far back as 1947, such a rectifier was installed to power a large flanging machine at Lukens Steel Co., and many more of these devices have been used to power various rolling mills.

Up until April 1 of 1959, when the new installation at Lukens went into operation, no mercury arc rectifier had been used in this country for large rolling mill drive reversing duty.

In Europe, notably in West Germany, there are a number of such installations in operation, the reversing feature being obtained in various ways. These can be classified into three types of rectifiers with respect to the reversal method utilized. One of these types obtains its reversal by means of an armature circuit polarity reversal switch controlled to operate at a low value of current; another type utilizes motor field reversal to provide its reversing function. The third type is actually two complete rectifiers, one being utilized to drive the mill motors in one direction, while the other rectifier provides the opposite armature polarity and therefore the reversal in direction.

Of these types prevalent in Europe, the first is the most numerous. It has been said that the presence of a large mechanical reversing switch of extremely high current capacity may be a source of production delays and maintenance expense. Most certainly it is a moving part of great importance, however, the European experience indicates that it is a reliable device which gives little trouble. The installations we have seen employed only one switch of this type, and one would think that if it were a source of delay, certainly two such switches would be provided. The motor field reversal type of rectifier has at the moment an inherently slow reversal time. It is possible that motor redesign, together with extreme field forcing, may in the future correct this point. The third type of rectifier, which is commonly referred to as the "back to back" connected rectifier, was the type utilized at Lukens Steel Co. to power the 10,000-hp twin drive, 40/80-rpm motors, for the new 140-in. slabbing mill.

With this background data in mind, the following will develop the reasons why the mercury arc rectifier was selected as a good investment. In this case, the rectifier was considered versus the flywheel motor-generator set. The synchronous motor-generator set was not considered, due to the very high peaks such equipment would impose on the public utility system when machines of this capacity are utilized. The elimination of the consideration of the synchronous motor-generator set for this reason is not unusual, since the majority of utility systems supplying steel mills would be unable to accept such peaks.

Since any piece of production equipment or process is rated, not according to its novelty or theoretical engineering correctness, but in accordance with our economic system by the integration of three main factors, namely—initial cost, effect on construction schedule, and profitability in operation, the application of this rectifier will be covered in reference to these three criteria.

A close look at the item of initial cost would indicate that it is composed of four parts. These are: (1) the initial equipment cost as purchased from the electrical manufacturer; (2) the installation cost of the equipment including foundations, construction materials, wire, conduit, bus bar, etc.; (3) the cost of construction of the area or volume of space in which the equipment is to be installed; and (4) any cost which may accrue due to possible required changes in utility power supply systems.

The mercury arc rectifier as a means of securing power for a mechanical drive has historically been priced at a higher level than the equivalent Ward-Leonard equipment. This is still true if only the rectifier and its equivalent flywheel motor-generator set are compared. If, however, all of the equipment from the high voltage power feeder to the main drive motor mill spindle couplings are considered, one may as a broad and sweeping statement, which admittedly needs further definition, state that the initial costs are equal.

Qualification of this statement may be expressed by specifying the equipment generally for which it would hold true.

Select as an example a main mill reversing drive of 10,000-hp consisting of two 5000-hp, single-armature, 40/80-rpm, twin drive motors equipped with Class "B" insulation and arranged for integral ventilation.

This drive may be supplied by either a flywheel motor-generator set equipped with Class "B" insulation and integrally ventilated complete with excitation sets, slip regulator and mill control panel all supplied from 13,800 volts; or an 8000-kw rectifier complete with oil-insulated self-cooled, outdoor main transformers, indoor self-cooled interphase transformers insulated with a noninflammable liquid, cathode breakers, water-to-water heat exchangers, motor field excitation rectifiers and a mill control panel also all supplied at 13,800 volts; for the same total initial cost of equipment.

Variations in this specification will, of course, upset the equality of initial cost. For instance, the addition to the mill of a close-coupled edger powered by a 3000-hp, double armature, 150/375-rpm, integrally ventilated motor equipped with Class "B" insulation would create a differential cost of 4 per cent between the rectifier and the motor-generator set; this difference being in favor of the motor-generator set. This is logical from the standpoint that the motor-generator set cost increases due only to the addition of generator capacity and drive motor hp, but an additional rectifier consisting actually of two rectifiers, one for each direction, complete with supply transformers, must be added to accommodate the edger load.

If, as in the case of Lukens Steel Co., the edger is separated from the mill a sufficient distance to preclude simultaneous loading of the mill and edger, the same source can be used to supply both, and the initial cost differential disappears.

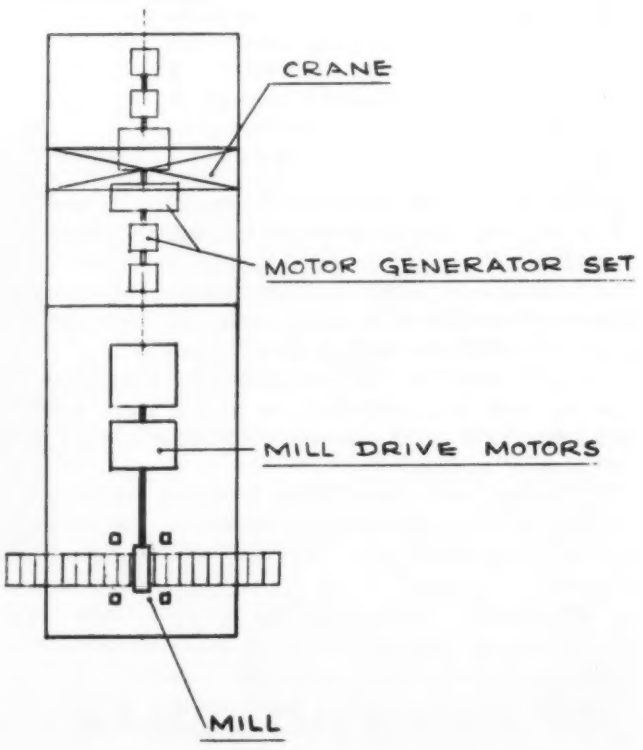
Also, variations in the application and refinement of air cleaning, recirculating and cooling systems; the possibility of lack of cooling water; and other possible modifications to the example specification will tend to alter the initial cost equality between the rectifier and the flywheel motor-generator set.

It should be further emphasized that even though a small percentage cost differential between the rectifier and motor-generator set may exist, we are dealing with equipment whose initial cost is approximately $3,250,000, and even one per cent differential is a large amount of money.

The initial installation cost of the rectifier and the motor-generator set was investigated at quite some length. As previously stated, installation costs include foundations, the cost of installing the purchased equipment and the cost of the necessary construction materials including the conduit, wire and bus bar. In this particular case, the site of the main drive equipment was such that a solid rock outcropping is present approximately 10 to 12 ft below the original ground surface. The mill floor elevation was maintained approximately 3 ft higher than the original ground elevation as a result of historical information concerning plant floods. This provided a relatively uncomplicated solution for the design of a motor-generator set foundation. Engineering estimates of the cost of providing such a foundation and installing a motor-generator set indicated a figure in the neighborhood of $80,000.

This included the installation of the motor-generator set, slip regulator, switchgear, oiling system, mill control panel and the necessary excitation equipment for control and motor fields.

Figure 1 — Installation of the motor-generator set, main drive and the mill proper in the same bay requires only one crane for service.



The equivalent installed cost of the rectifier, which of course required no foundation, was estimated at $36,000, which included the rectifier, two main power transformers, four cathode circuit breakers, four interphase transformers, water-to-water heat exchangers, a mill control panel and rectifier type excitation equipment.

Furthermore, since it was possible in this particular case to install the rectifier closer to the main drive motors than the motor-generator set, it was also estimated that a difference of $10,000 would exist in favor of the rectifier for the purchase and installation of the main drive motor leads.

It becomes apparent, that in equipment of this capacity, the cost of installation of the rectifier is approximately 40 per cent of the cost of installation of the motor-generator set. Naturally, site conditions will cause this picture to change, but since it is felt that site conditions were most favorable for the installation of a motor-generator set foundation, it was also felt that such changes could only result in favor of the rectifier.

The third factor, included in initial cost, is the cost of the area in which either the rectifier or the motor-generator set is installed. In order to develop a background for discussion of this point, it would be well to describe the three usual layouts of mills and their drive equipment as related to building structures.

The first of these layouts (Figure 1) indicates a mill and its associated main drive equipment installed within one bay of a building structure, the axis of the drive of the mill being parallel to the length of the bay. In this layout, a single crane usually services both the main drive equipment and the mill equipment. If we assume that only one crane is provided for service, the layout, while possessing the economic advantage that it requires only one crane, possesses a number of operational disadvantages. During either planned or emergency shutdown it is very difficult to schedule crane time between the mill and the main drive equipment, resulting in either a protracted shutdown or postponement of some of the items of work resulting in future emergency or scheduled "downtime." During mill operations more than one crane operator is required in the event of trouble with pieces along the mill tables which, of course, extend out of the mill bay. If an enclosed pressurized motor room is utilized, a door must be provided for crane access, which in itself is a source of some trouble, and in addition, the crane which usually remains in the mill area contributes a fair amount of dust and dirt to the motor room whenever it is utilized in this area. Substitution of a rectifier for a motor-generator set in this layout would result in the shortening of a building of heavy construction, since either a lean-to or a basement could be utilized for its location. In some cases site conditions or existing buildings may make it impossible to locate a motor-generator set near the main drive motors. Utilization of a rectifier would provide shorter main leads in such cases.

The second commonly used layout (Figure 2) involves putting the mill and associated tables in one bay, and perpendicularly to this bay erecting another building containing the main drive equipment. This plan, of course, requires two cranes—one in each section, however, all of the disadvantages of the first layout have now been eliminated. In this case there may be some difficulty, in the case of a twin drive, in working on the motor and jackshaft mill end bearings due to their close proximity to the junction of the two building sections. Also, it should be pointed out in connection with this example that it is not possible to utilize the bay containing the main drive equipment for any productive purposes other than housing this equipment. After installation work has been completed on the main drive equipment, the duty cycle on a very expensive crane is very low, and in the true sense of the word, this criteria can be applied to the building structure itself, which must be of heavy enough construction to carry the crane. As in the first layout, the substitution of a rectifier in place of a motor-generator set can result in a shorter building.

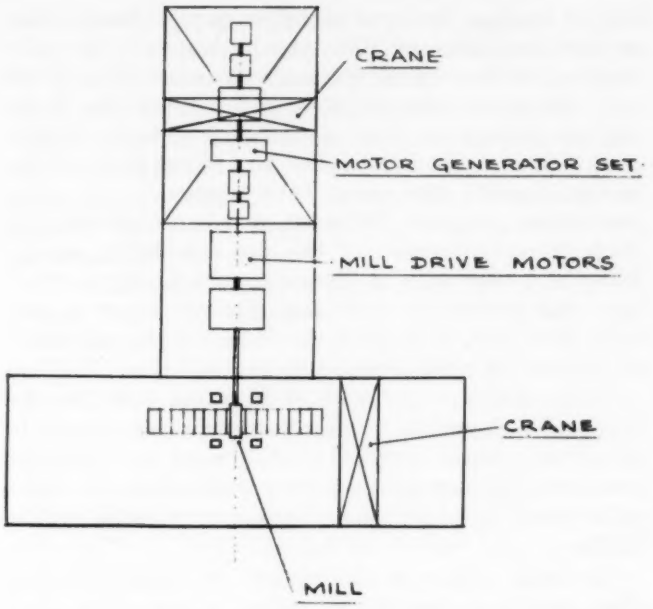
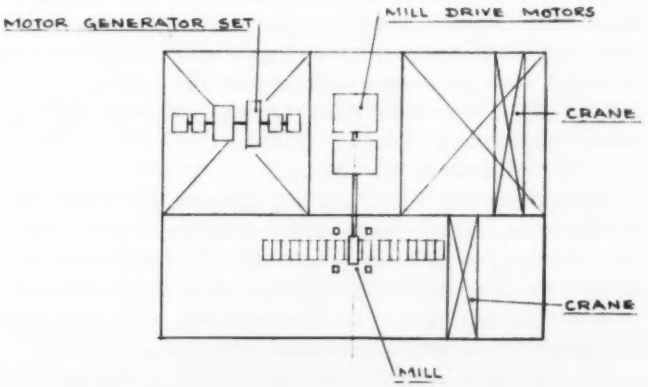


Figure 2 — A perpendicular arrangement of the main drive and motor-generator set, with relation to the mill proper, removes the disadvantages of the single bay installation.

The third layout (Figure 3) indicates the mill installed in one bay and the main drive equipment installed in a parallel bay. This plan also requires two heavy

Figure 3 — A parallel installation of the mill proper with relation to the motor-generator set and the main drive allows use of part of the main drive building for productive purposes.



cranes, and has the same objection as plan No. 2 as far as the possibility of difficulty in handling the mechanical items between the main drive motors and the mill, due to the fact that they pass through the center line of columns between the building sections. In this case, however, it is possible to utilize part of the section housing the main drive equipment for some productive purposes. When we consider that mill and main drive equipment, of the size concerned, require 100-ton cranes with a commensurate building structure, the possibility of obtaining as much use as possible from the investment in them is of paramount importance. Construction costs indicate that buildings of this type equipped with such cranes cost between $35 and $40 per sq ft, therefore, in cases where the productive space supplied in the same building section can eliminate the need for constructing equivalent space elsewhere, this point becomes particularly valuable.

Looking further at this layout, it is apparent that the length of the main drive motors and their spindles would preclude the installation of a motor-generator set perpendicular to the axis of the main drive motors and between them and the outer building wall, so that some of the generators are at one side of the main drive motors while the remainder of the generators are on the opposite side, without providing a building span which would be economically out of reason, due to increased truss and crane costs, or without eliminating access from one side of the main drive to the other along the length of the building. In such a case it would seem logical, therefore, to install the motor-generator set either totally on one side of the main drive motors or the other. In this case, the length of the equipment is such that approximately 3000 sq ft of floor space will be occupied by the motor-generator set, and the main motor leads will be much longer. If in addition, the pressurized motor room type of construction is utilized instead of integrally ventilated main drive motors and motor-generator sets, considering the need for "take apart" space and possible spare generator armature storage, the area required for the installation of the motor-generator set will be even larger.

If we then consider the use of a rectifier with this type of layout, it is logical to place the rectifier in a lean-to along the outside wall of the building or in a basement adjacent to the main drive motor foundations. This provides short main motor leads and releases the remainder of the area for productive purposes, thus increasing the duty cycle on both the 100-ton crane and the building structure. The evaluation of these various plans is admittedly very difficult to make. However, if the use of productive space is known in advance and the work load or amount of production which will be put through these spaces can be estimated, some type of evaluation can be made. It will, of course, vary in each individual case.

In connection with any rectifier application, the problem of interference with communication lines should not be forgotten. While this effect has been minimized by the design of multiphase rectifier equipment, it would be asking for trouble to install such a rectifier in close proximity to communication lines.

The last item, making up the initial cost, is the cost of any public utility power supply changes which may be necessary due to the installation of rectifier equipment. In the case of a flywheel motor-generator set, power demands have been well worked out, and peaks on the public utility system can be predicted with accuracy. This prediction can also be made in the case of a rectifier drive, but due to the absence of any flywheel in connection with the rectifier, the peaks are correspondingly greater and this subject must be investigated thoroughly in order to determine the capability of the public utility system to accommodate them. These matters are handled differently with each individual company, and one can make no estimate of any cost differential in favor of the motor-generator set in connection with this point, however, consideration of this item rightfully belongs as a portion of the initial cost comparison.

Since main mill drive equipment represents a large portion of any project of this type, the equipment and its installation may at times be a controlling factor in the construction schedule for the project. This brings up the second main criterion for the comparison between the rectifier and the motor-generator set.

Once a plan is formulated for the addition of a facility or process to a company, and money is set aside to accomplish this addition, the time intervening between these steps and the actual beginning of operation may be regarded in the same manner as the time lost when operations cease due to a breakdown in existing equipment. In both of these cases, the investment is idle. Due to the importance of this fact, both the rectifier and the motor-generator set should be analyzed to see whether the inherent differences in these equipments permit one or the other to be received and be installed with a materially shorter construction time.

The first item of this analysis is the lead time required to manufacture main mill drive equipment equipped with a rectifier, versus the same equipment motor-generator set powered. To date, any of the manufacturers who produce motor-generator sets and main mill drive motors build these equipments, if not in the same building, in the same production organization. This is only logical due to their inherent similarity. The rectifier, consisting of transformers, switchgear and the rectifier proper, again comparing the present organization of the same manufacturers, would be built in entirely different production organizations than the main drive motors. In normal times main drive equipment equipped with a motor-generator set and the same equipment rectifier powered can be produced in approximately the same length of time. However, during abnormal conditions such as World War II and to a limited extent the Korean crisis, it is probable that main drive equipment, rectifier powered, could be produced in less time than the equipment supplied by a motor-generator set. The importance of this point is questionable, due to the fact that in most cases of this type a complete new mill is necessary, and in abnormal times this will probably be the limiting factor in the estimate of lead time for manufacturing.

The construction schedule must also contemplate the time required for the providing of an area in which the main drive equipment will be installed. It is logical to assume that the building volume, capacity of build-

ing and crane service which will be necessary to house the main drive mill motors will take less time to build, than a larger building of the same type of construction occupied by both drive main motors and a motor-generator set. If integrally ventilated machinery is not utilized, and cooled and pressurized motor room construction is provided, the added complication of the provision of space for air cleaning and cooling equipment, together with space for fans and air ducts, when translated into the construction schedule of a heavy building, with the consequent schedule integration of additional trades, logical reasoning would indicate that additional time would be required to provide such areas.

The rectifier inherently requires no motor room, nor does it require the services of a heavy crane, so it may be placed as mentioned before, either in a basement area which can be constructed at the same time as the main motor foundations, or in a convenient lean-to area.

Although other considerations may prevent the time reduction of a construction schedule, due to the ease of furnishing an area for a rectifier, at least it appears that the opportunity and possibility exist and depending upon circumstances may save considerable construction time.

Finally, any consideration of the construction schedule for a main mill drive must also include a comparison of the ease of installation of the rectifier versus the motor-generator set. In the case of the motor-generator set, a very heavy foundation, which will vary in complexity and time of schedule due to site conditions, is required. Due to the amount of concrete and form work involved in such a foundation, in addition to the amount of concrete and form work in the main mill drive motor foundations, it would be most unusual to see these foundations constructed simultaneously. The rectifier, on the other hand, needs no foundation, requiring only a volume of space and a simple pad or platform for its installation. In most construction schedules the elimination of a motor-generator set foundation would represent a definite improvement in timing.

Since the leads between the power source and the main drive motors are extremely heavy, appreciable schedule time is required to procure and construct them. In most cases it is possible, due to the space flexibility inherent in rectifier equipment, to install the rectifier closer to the main drive motors than is possible with a motor-generator set. This will allow the main leads to be shortened, which may produce a reduction of construction schedule time.

It has already been mentioned that it is necessary to supply a heavy crane in order to handle both motor-generator set and main drive motor assembly. It is logical to assume, therefore, that with only one crane, it would be unwise to schedule the assembly of both a motor-generator set and its main drive motors simultaneously. If the same crane also services the mill proper, a greater scheduling complication results. Since the rectifier does not require a crane for its installation, it can be installed simultaneously with the main drive motors from a material handling standpoint.

In addition, trade and craft groups, normally engaged to install the main drive motor equipment, would also handle motor-generator set equipment. Unless two similar groups are employed to handle both of these units simultaneously, the installation of one must necessarily follow the installation of the other. Therefore, in certain areas, or during labor shortage conditions, it might well save time to apply a rectifier, since the trade and craft groups which would be employed for installation of the rectifier are entirely different, than those employed in installing main drive motors.

The third and last basis of comparison in this evaluation is profitability in operation. Due to the short time that our rectifier has been in use, we can only relate the points which compose this consideration and provide the estimates on which we based our comparison.

The consideration of profitability in operation is composed of four parts which are—power cost; the cost of maintenance, repair and attendants; the cost of loss of production due to downtime; the return from exactitude of control; and the return from increased usage of heavy cranes and building structures.

In connection with the first item—power cost, using the relative efficiency of the motor-generator set and rectifier which are respectively 82 and 92.5 per cent and assuming that the average power cost is 1¢ per kwhr, reference to slabbing mill loading curves, when translated back to the input of the conversion equipment, indicate an approximate difference of 1.2¢ per ton in favor of the rectifier. If we assume a mill operation time of 6000 hr per year and a production rate of 800 tons per hr, which is the maximum equipment capability capacity, the net saving in power cost for the rectifier application would be in the neighborhood of $57,000. Based on present steelmaking facilities, at Lukens an average production rate of 150 tons per hr can be attained. Estimated at 1.2¢ per ton this would yield a power cost saving of $10,800 per year.

In connection with power cost, we would point out that the method of operation of a rectifier driven mill is very important, from the standpoint that operation under load at less than base speed will produce high reactive kva peaks, due to the inherent poor power factor of the rectifier at less than rated voltage. If operation at less than base speed is not indulged in, the reactive kva for the rectifier during rolling is approximately the same as the motor-generator set. Due to the presence of power factor penalty clauses in most power contracts, it is wise to consider this point thoroughly.

In arriving at the maintenance, repair, and attendant cost difference between the motor-generator set and the rectifier, since we had an equivalent capacity flywheel motor-generator set in operation, we used actual maintenance expenditures, spare parts, and repair costs prorated over a 15-year period arriving at a net cost for the flywheel motor-generator set of $3876 per year as compared to an estimated $12,000 per year for the rectifier. In this case, tube replacement for the rectifier creates the large differential. If, in addition to these costs, we consider over a 30-yr period the complete rewinding of the motor-generator set as compared to the rebuilding of the rectifier transformers, we obtain a cost differential per year of $3583 in favor of the rectifier.

We must also evaluate the cost of cooling water for the rectifier. The equipment will use approximately

30 gal of make-up water per min in a recirculating cooling system and in this case we estimated the cost of this water at $2000 per year.

It is the accepted practice, with the use of large flywheel motor-generator sets, to keep an attendant on hand in the area at all times during mill operation. In considering the rectifier as a source of power for this drive, it was felt that the maintenance groups stationed in the area could handle this function on a patrol basis and conservatively estimated a saving in favor of the rectifier, for this reason, of $12,000 per year.

As a result of all of these pros and cons the final summation indicates an estimated savings of approximately $5500 a year in favor of the rectifier when each of the items making up the cost comparison are considered on the bases previously stated.

These first two points making up a portion of the study of profitability of operation are tangible items. It is readily seen that the possibility of a savings from $16,000 up to approximately $62,500 per year can be secured by using a rectifier in place of a flywheel motor-generator set. The remaining three points to be still considered represent intangibles and cannot be evaluated as directly.

Usual schedules for mills of this type provide downtime each week for maintenance purposes. Experience with the flywheel motor-generator set would indicate that it is most unusual to incur a production delay which can be attributed to failure of the motor-generator set. Likewise, experience in Europe indicates a similar state of reliability for the rectifier. In our case, outside of the usual problems in new equipment, these statements have, to date, been borne out. If we consider, however, the period at the end of approximately 30 years, when the motor-generator set must be rewound, realizing that this may be done with very little or no downtime by the substitution of spare units with their consequent addition to inventory cost, or step by step, accepting downtime and consequent loss of production, compared to the fact that the rectifier at the end of 30 years has, with the exception of its transformers, been completely replaced many times, component by component, with no downtime, it is probable that loss of production may be avoided during this stage of the life of drive equipment, by utilizing a rectifier. The provision of two spare rectifier transformers, one of them a main transformer and the other an interphase transformer at a much lower inventory cost than spares for the motor-generator set will prevent production losses when transformers must be rebuilt.

While control of the motor-generator set has developed, through the use of both static and rotating amplifiers, to a high degree of efficiency the inherent nature of the equipment with its built in time constants and inertia does not permit the exactitude of control possible with the rectifier which has no inertia. Notably, current limit and the rate of change of current can be controlled in connection with the rectifier equipment in such a way as to allow the main drive motors to get everything possible out of the conversion equipment. While this difference in control is probably very small when related to a difference in the amount of production, and as yet, lack of experience does not indicate the degree this difference may attain, it is logical to feel that there will be an increase in production for this reason.

The last item in this study of profitability of operation is the return which may be secured from the use of productive areas, providing they may be incorporated in the mill layout, under the same heavy crane as the

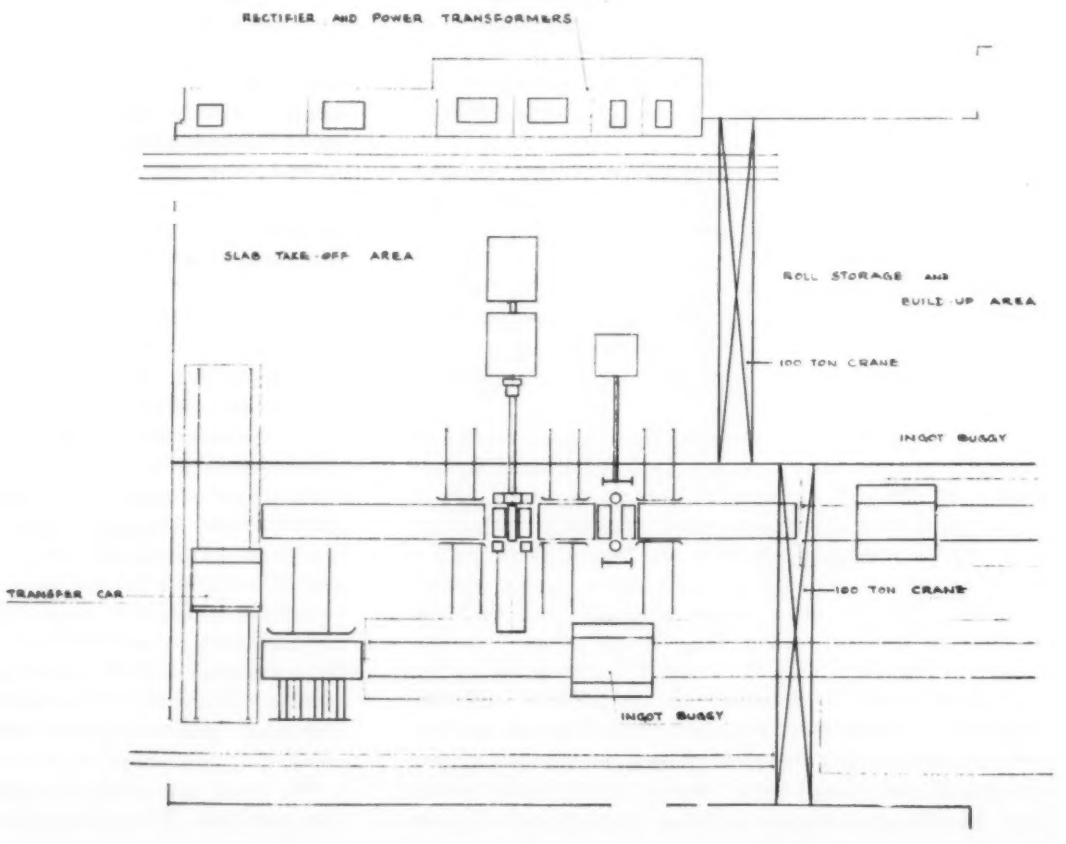


Figure 4 — General arrangement of the mill and main drive indicates that all possible areas are used as productive space.

mill drive motors. This point, of course, was mentioned before in connection with initial cost.

This concludes the analysis of application of the rectifier versus the flywheel motor-generator set. In this case a thorough consideration of each of these points and their consequent integration resulted in the application of the rectifier equipment now installed at Coatesville. The mill and the main drive equipment are installed in two parallel mill bays, while the rectifier and its associated equipment is installed in the basement adjacent to the mill motor foundation. In our case, a separate heavy edger was installed 33 ft from the mill and the same mill drive rectifier was used as a power source for the edger. In the basement are located the rectifier, the main drive motor and edger foundations, the high voltage switchgear, the field excitation rectifier and the mill control panel. In addition the mill auxiliary control was located in this basement, and in separate sections of the basement, were located the hydraulic descaling system and the mill and main motor oiling systems. The flumes for carrying scale from beneath the mill and the settling basin from which we recirculate our roll cooling and scale flushing water is also shown.

The arrangement of the mill and main drive motors on the mill floor is shown in Figure 4. Note that the areas to either side of the mill main drive motors are used as productive spaces. The area on the left is a hot slab take off area, and the area on the right is utilized for roll storage and roll bearing build-up. The area immediately outside of the building wall at the top of the diagram allows for the mounting of all of the transformers and a second story projecting over this area provides the mounting for water cooling towers for the recirculating water cooling system as well as providing space for air fans for a small amount of make-up air for the integrally ventilated main drive motors as well as the forced ventilated mill auxiliary motors.

The mill and the heavy edger immediately behind it are shown looking from the north end (Figure 5). The control pulpit is located between the main mill and the edger.

The main mill motors and the edger motor are seen in a view taken during construction (Figure 6). In the immediate foreground is the hot slab take off area and the prefabricated building to the left of the edger motor foundation houses the mill automation equipment.

Experience with this rectifier to date has been very good, and no fundamental difficulties have developed which would indicate that the selection was in error. Since the rectifier is constructed in sections, adjustment and a portion of the tune-up proceeded simultaneously with installation, and this in effect, even on this first installation, was to maintain tune-up time equivalent to the time usually spent on motor-generator set tune-up. Admittedly there have been some problems in components. This was expected since this type of difficulty is always present with first installations. The rectifier equipment is highly circuited for trouble indication, and during the installation and tune-up the maintenance personnel were on hand to absorb all of the information possible which would subsequently aid them in "shooting trouble."

The main purpose of this paper has been to provide a check list of the items felt worthy of consideration concerning the application of this type of apparatus, as well as a sample evaluation of each of these items in terms of conditions at Lukens.

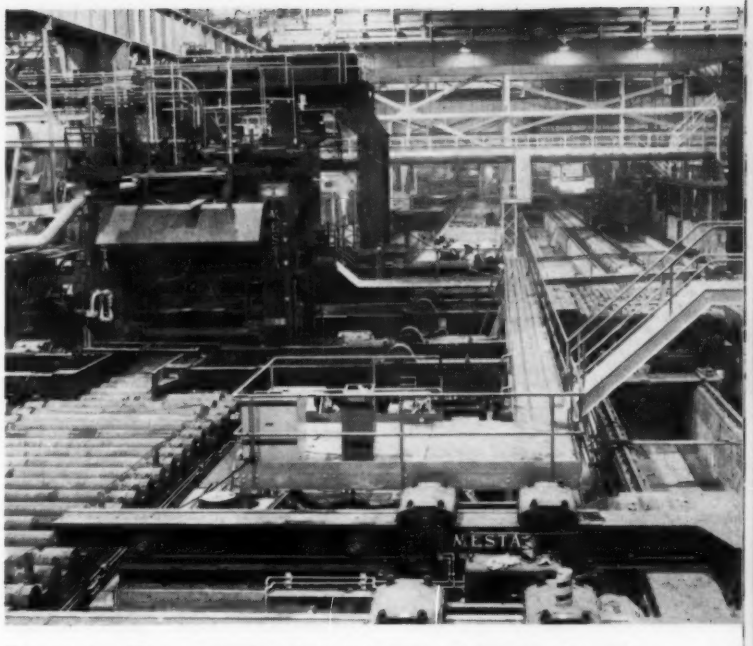


Figure 5 — The control pulpit is located between the mill proper and the edger.

Discussion

PRESENTED BY

H. H. ANGEL, Electrical Engineer, Construction Engineering Dept. Bethlehem Steel Co., Bethlehem, Pa.

J. H. GREINER, Supervisory Engineer, Metal Industries, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

J. A. B. PINNEY, Assistant Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

M. B. ANTRIM, Manager, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

G. M. ZINS, Manager, Ignitron Rectifier Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

H. W. DORSET, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

C. E. RETTIG, Manager, Rectifier Circuit Development, General Electric Co., Philadelphia, Pa.

H. H. Angel: Mr. Antrim has given us good background data on the subject of rectifiers and motor-generator sets and has made very good cost comparisons between them but he touches only lightly on one of the three types of rectifiers with respect to the reversal method utilized, namely; the motor field reversal type. He states that at the moment it produces an inherently slow reversal time, but motor redesign, together with extreme field forcing, may in the future correct this point. I would also believe that this method would produce slow reversal time. However, in a brochure put out by one of the European equipment

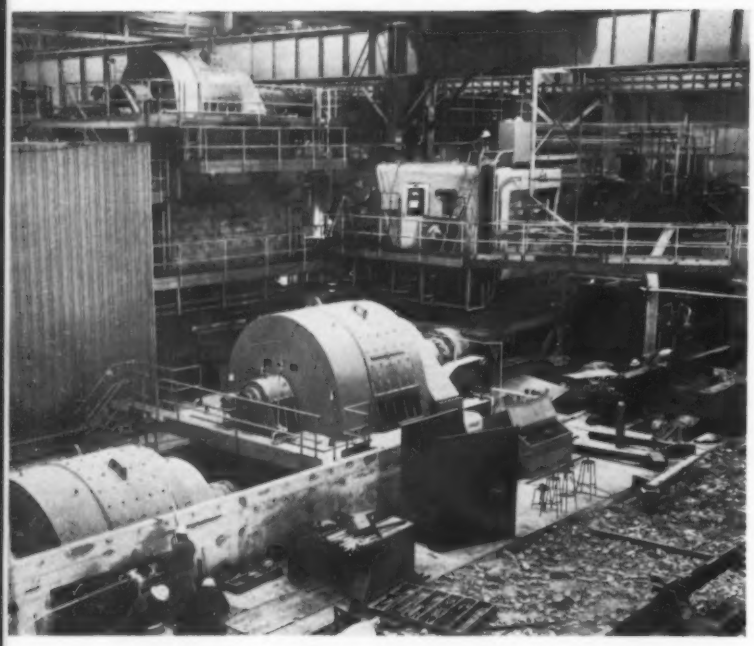


Figure 6 — The installation of the required equipment was greatly simplified through the use of rectifiers.

manufacturers, it was stated several years ago that the principle of field reversal was further developed. To quote—"With an appropriate design of motor and by selecting the correct impulse excitation, it is not difficult to achieve dead times and therewith reversing times of the same order of magnitude as those obtained with pole changing and, in addition, to fulfill the most exacting requirements."

The author stated that the price comparison was made between rectifier and flywheel motor-generator set since the synchronous motor-generator set would draw very high peaks on the public utility system. I was of the opinion that the rectifier would draw peaks nearly as high as for synchronous equipment. Possibly the author can give us some peak figures in kw and kva.

J. H. Greiner: I would like to limit my remarks primarily to a superficial explanation as to why a synchronous motor-generator set imposes heavier peaks on the power system than a rectifier. Since either scheme has no possibility of releasing energy from a flywheel, it appears at first glance that both would impose the same load on the power system. However, it must be remembered that a synchronous motor rotor behaves like a torsional pendulum when a sudden load is applied. This is due to the so-called elastic effect of the flux in the air gap. When the rotor is shifting from its no load position to its new steady state position, it momentarily overshoots and at this time an excessive peak is encountered which is of a transient nature. However, there are various factors that designers can manipulate to keep this overswing to a minimum.

One other brief point is if an armature reversing switch is used in conjunction with a rectifier it should be made with drawout features to minimize downtime in case of trouble.

J. A. B. Pinney: We at Alan Wood are planning an expansion program which will include a 40-in. blooming mill and 110-in. reversing plate mill with attached edger. Due to the power savings which could be realized by the application of rectifiers, main drive systems were carefully analyzed. Our study covered the factors mentioned by Mr. Antrim and some others which are peculiar to our particular plant.

Mill arrangement will be such that it would be impractical to install the rectifier transformers outside of the motor room and realize that building cost saving. Also, while the expense of a motor room crane is certainly undesirable, it will, in our case, be available to install and service mill auxiliary motor-generator sets in addition to the main drive equipment.

Installed costs of electrical equipment favor motor-generator sets by 4 to 10 per cent, depending upon whether the set is synchronous or flywheel. Expected power savings would take several years to offset the higher first cost. In our case, maintenance costs would appear to be about equal, particularly since it is not our practice to use motor room attendants.

Some of the other factors considered were power system peaks, power factor and fault contribution. The increase in plant load due to the expansion program will require a new power company service at a higher voltage. The new service will remove any problem of peaks as far as the power company is concerned. However, these peaks would cause reasonably high flicker voltages on our 6900-volt system in the case of synchronous motor-generator sets or rectifiers which are loaded at less than top voltage.

The inherently poor power factor of the reversing rectifier presents a serious problem to us. While rectifier drives for the two mills mentioned previously would be acceptable now, continued expansion will result in the removal of a large synchronous motor-generator set from our system and replacement with nonreversing rectifiers for a strip mill finishing train. Unless it is planned to install power factor correction equipment as our expansion continues, we could use the reversing rectifier only on the smaller of the two mills.

Fault contribution can become quite important if it is necessary to install reactors to reduce fault currents. Since the rectifier will not contribute to primary system faults as will motor-generator sets, it may be possible to effect some savings on reactor costs in the case of rectifier applications.

As was indicated by Mr. Antrim, various factors depending on job site, mill arrangement, installed costs, effect on power system, power savings, maintenance costs and so on must be considered for each application before the choice of a main drive system can be made. Perhaps, as the electrical manufacturers gain more experience in reversing rectifier design and construction, prices will become more nearly equal to that of motor-generator sets and the decision will become less complicated.

Two questions which I have on Mr. Antrim's paper are:

1. Even though the edger is detached from the mill, would it not be possible, due to the length of the slab, to edge while the slab is still in the mill? How is this prevented? How is the switching accomplished? Could not a generator be switched also?
2. What type of training program was held for maintenance personnel? What calibre of personnel actually "trouble shoot" on the rectifier?

M. B. Antrim: The motor field reversal type of rectifier, which Mr. Angel mentioned, has been applied in Europe to some drives rather small in hp and it is quite true that acceptable reversal time can be provided with this type rectifier, providing the main drive motor design is such that rapid magnetic field reversal and the possibility of applying extreme field forcing can be applied. If we are to utilize this method on large reversing rolling mill drives, it will be necessary for motor designs to be varied to permit this rapid field reversal. Since the design of large rolling mill motors has evolved due to both ingenuity and experience, a drastic change in these designs would be a time consuming action. It will then be necessary for the electrical manufacturers to anticipate the offering of a field reversal type of rectifier by completing a change in motor design before such an application is actually ordered for installation. It has been our experience that once the order is placed for a mill drive, speed of delivery becomes most important.

The synchronous motor driven motor-generator set was omitted from the comparison portrayed in the paper for the following reason. The torsional behavior of the synchronous motor, when subjected to impact loads produce large reactive kva swings and their consequent voltage variations on the utility power supply system is now quite well known. Many things can be done in the design of synchronous machines to alleviate this condition but unfortunately none of these things cause the synchronous motor to cost less. Generally, designing a synchronous motor which has a very high pull-out torque aids this condition materially. Such a motor, of course, would under ordinary circumstances have too much hp for the drive except for this one condition.

In attempting to get some relative comparison between a flywheel motor-generator set, a synchronous motor-generator set, and a rectifier by setting up assumed conditions involving a typical rolling schedule, mill drive motors of a particular hp, etc., it becomes quite evident that such a calculation must be made for the particular utility power system to which these devices are to be connected. Quoted figures, therefore, are not complete unless they specify the characteristics of the utility power system to which they apply.

Therefore, accepting the risk that figures may be used without complete identification, we can state that if we assume a twin drive 10,000-hp rolling mill, impact loaded at 225 per cent and supplied from a 13,800-volt bus which is in turn supplied from a moderately stiff power system, the percentage transient voltage drops which will occur on the supply 13,800 volt bus can be calculated and are listed as follows:

Synchronous motor driven generator set, with standard synchronous motor—8 to 9 per cent
Flywheel motor-generator set—3 to 4 per cent
Rectifier—4 to 5 per cent

In connection with the synchronous driven generator set it must be remembered that as the reactive kva becomes larger and a voltage drop ensues, it is possible, due to the accumulative effect of the synchronous motor drawing more and more reactive kva as the applied voltage drops, to pull out of step entirely.

TABLE I

	On critical power supply bus	On load bus
Synchronous motor driven generator set	3.8	10.2
Flywheel motor-generator set	1.6	3.9
Rectifier	2.5	6.7

In connection with the above illustration, if we make the same assumption concerning mill horsepower and loading with the additional effect that at the same time the impact load occurs another mill, powered at the same horsepower but driven by a flywheel motor-generator set, is simultaneously impact loaded, we can arrive at the percentage transient voltage drops by calculation shown in Table I.

May we again caution that the above tabular figures mean nothing to a particular application since this must be calculated based on its own power supply. In the above tabulations the rectifier was considered at full voltage. In other words, load was not applied to the mill drive at less than base speed.

Concerning Mr. Pinney's question regarding the separate edger which is powered from the same rectifier supply as the main rolling mill drive, we might state that we chose a distance of 33 ft from center to center of the edger rolls and the main mill rolls in order to eliminate the possibility of loading both the separate edger and the main mill at the same time. In the event it would become necessary to roll a piece which would extend this distance, it is still not necessary with proper operation to load the vertical and the horizontal mill simultaneously.

The edger is supplied in parallel with the bottom roll drive motor through its protecting circuit breaker and a large contacter. The edger is actuated when edging passes are required by closing this contacter. This operation is performed from the operator's pulpit. It is apparent in this case that the edger need not operate when the main mill drive is running, however, the main mill drive will operate when the edger is taking edging passes on a slab. There is nothing novel about this method of control and it could be employed with the conventional motor-generator set.

The training program necessary for maintenance personnel on the type of complex and sophisticated controls inherent with the rectifier and the mill automation is of prime importance. In the course of investigation of rectifier drives in Europe, one of the chief complaints of the various operating people in many of their plants was the fact that trouble on main mill drive rectifiers was very difficult to find. As mentioned in the paper, our rectifier is very highly circuited for indication of trouble and we hope that by this method this complaint will be eliminated. It then becomes necessary to develop the knowledge of maintenance personnel so that they can correct the trouble once it is spotted.

In our case we assigned some top-flight maintenance personnel to observe the installation of the equipment and work right along with the manufacturer's engineers during the adjustment and "debugging" stages of the installation. As time passes these people will train others in actual "trouble shooting" and component replacement work.

G. M. Zins: Although this paper is slanted primarily at reversing mills, certainly many of the factors involved in the analysis are applicable to a comparison of electronic power converters and motor-generator sets for any application.

It is particularly gratifying to see the rather favorable status that the electronic power converter enjoys when all of the related factors in this economic analysis are considered. I believe that too many times in the past many of these significant factors were not included in economic surveys, with the result that the initial equipment cost was given undue weight in the analysis.

By way of example, our own company has made a study of a 10,000-hp reversing mill. Using the flywheel motor-generator set as a base of 100 per cent, the synchronous motor-generator sets ran 93 per cent and the electronic converter ran 105 per cent. These percentages include initial equipment costs and installation costs. This analysis did not include many of the economic factors included by Mr. Antrim. The inclusion of these additional factors has enhanced the status of the electronic power converter considerably.

Admittedly, many of the factors introduced by Mr. Antrim are difficult to evaluate accurately; however, they are factors and an attempt should be made to evaluate them as honestly as humanly possible. This paper will serve as a guide to analyzing future applications and represents a valuable contribution to the steel industry.

There is one specific point I would like to raise with regard to this paper.

The relative figures on maintenance indicate $3876 per year for the motor-generator set as against $12,000 per year for the rectifier. It has been generally conceded in the past that rectifiers have a lower maintenance cost than motor-generator sets. This has been evidenced by the fact that rectifiers have almost universally replaced motor-generator sets in the electrochemical, mining and steel mill industries (for auxiliary power supplies). One major factor in this changeover was reduced maintenance. Mr. Antrim's figures do not appear to support these facts.

This naturally raises the question of why this is so. Mr. Antrim mentions the fact that the large differential in this maintenance was tube replacement costs. It is of interest to note that an AIEE Committee Report entitled "Survey of Operation of Mercury-Arc Rectifiers," dated April, 1952 shows that pumped type ignitron units, which were protected by anode breakers, required an average of 72 man-hours of maintenance per year per unit. For the eight units at Lukens this would be 576 man-hours total per year. Even assuming $4 per hr, this would result in a maintenance cost of $2304 per year, which would appear to be less than the major portion of the $12,000 figure.

If these figures are correct, it would appear that the pumped type of rectifier enjoys a considerable advantage over the sealed type of rectifier in the cost of maintenance.

H. W. Dorset: I am afraid I have to agree with Mr. Zins. We have one pump type rectifier at Sparrows Point that is 17 years old on which we have never replaced a tube. We have several of the pumpless type that we have purchased. They have been in operation for about a year and we have had to replace four tubes on these rectifiers.

C. E. Rettig: In comparing maintenance expense between pumped and sealed rectifiers Mr. Zins may have oversimplified the problem. Maintenance of a pumped rectifier has two parts: maintenance of the vacuum system and maintenance of the ignitron tanks. Even with conventional rectifier units where all tanks operate at a common potential, the maintenance of the vacuum valves, gaskets, mercury diffusion pump, oil pump and vacuum piping constitutes a very substantial part of the over-all maintenance expenditure. If the economics of the back-to-back connection used at Lukens are to be realized with pumped ignitrons, electrical insulation must be provided between tanks. Providing this insulation poses a real design problem. Placing a section of insulating pipe between each tank and the vacuum header is not easily accomplished because the condensed mercury which returns to the tank can provide a conducting path across the insulation. The alternative is to provide a separate vacuum system for each tank or at least for each different potential. For the Lukens rectifier this would mean at least 32 separate vacuum systems, a very substantial maintenance item.

Use of sealed ignitrons eliminates the vacuum system from the equipment and saves the associated maintenance.

The reconditioning cost of a sealed tube or tank can be compared directly with that of a pumped tank. The equipment required is about the same for either type, the principle items being a "clean room," a vacuum pumping stand, a degassing transformer, a firing circuit and a leak detector. The only special tool required for sealed tubes is the hydraulic ram for pinching off the exhaust tubulation. The same skills are also required of technicians who do the assembling, and testing for either type. The difference is that much tighter limits are placed on tolerable seepage rates and a more thorough degassing is performed on the sealed ignitron. This extra care in processing means that the sealed ignitrons can be put into service in a much shorter time than pumped ignitrons without any further degassing on load. This is a real advantage both on initial startup and on the replacement of tubes.

A user may consider reconditioning his own ignitrons if he has enough rectifiers to justify the required space, the initial cost and the trained technician. The initial cost of an air-conditioned room equipped for this work would be over $35,000 and the annual cost of one technician would be $10,000 (about $4.80 per hr). These figures should be compared with an average repair cost of $1000 for an ignitron reconditioned in our factory. Also, our experience with sealed ignitrons indicates an average life of 10 years (one half of the tubes replaced in 10 years). For the Lukens rectifier this calculates as $4800 per year average ignitron repair cost.

Chairman Dorset reported his experience with pumpless rectifiers which was both unusual and unfortunate. The total failures on pumpless tanks out of warranty has been less than 3 per cent of the total number installed since 1950. In Mr. Dorset's case the per cent of failures greatly exceeded this number. Of course the cause of each failure has been investigated and this investigation has lead to improvements which have already been incorporated into the design. ▲

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The rectifier will find its place in applications requiring high peak or continuous rated loads at rated voltage; acceleration or deceleration under no load, and high accuracy, fast response, or versatile control.

Figure 1 — The plate mill itself is powered by two 5000-hp motors while the vertical edger is driven by a 3000-hp single-armature motor.

Performance Characteristics of a Rectifier Powered Plate Mill

FOR the first time in the American steel industry a mercury arc rectifier has been applied as a power supply for a major reversing hot mill. This mill is the new 140-in. combination reversing plate and slabbing mill of the Lukens Steel Co. at Coatesville, Pa.

The main mill is driven by a 10,000-hp twin drive d-c motor (Figure 1). Each unit of the twin drive consists of a 5000-hp, 40/80-rpm, 750-volt motor. The top motor is located nearest the mill. The shaft of the lower motor passes under the upper motor providing maximum accessibility to both motors. A vertical edger associated with the mill is driven by a 3000-hp, 70/175-rpm, 750-volt, single-armature motor. Each mill and edger motor has a complete recirculating ventilating system including all necessary blowers, filters and heat exchangers built into the motor base.

Each 5000-hp main drive motor obtains d-c power from two 2000-kw reversing rectifiers. Since steel will not be rolled in both the vertical and horizontal mill rolls simultaneously, the power supply is used alternately to deliver power to either the mill or the edger drive motors. Figure 2 shows the main elements of the armature circuit for this mill. The transformer for each pair of 2000-kw reversing rectifiers consists of one delta-double wye transformer and one wye-double wye transformer in a common tank. Each 2000-kw reversing rectifier has two complete sets of ignitron mercury arc rectifier tubes; one set for forward power to the mill and one set for reverse power to the mill. The interphase transformers are located between the d-c output sides of the tubes from each half of the double wye instead of in the conventional location between the common points of the wye's. High speed circuit breakers and smoothing reactors are provided for both the forward and reverse rectifier outputs of each 2000-kw unit. The smoothing reactors perform a double function of reducing the ripple current which passes through the d-c motor and at the same time reducing the circulating currents between the forward and reverse rectifier units. A circuit breaker is in series with each motor armature

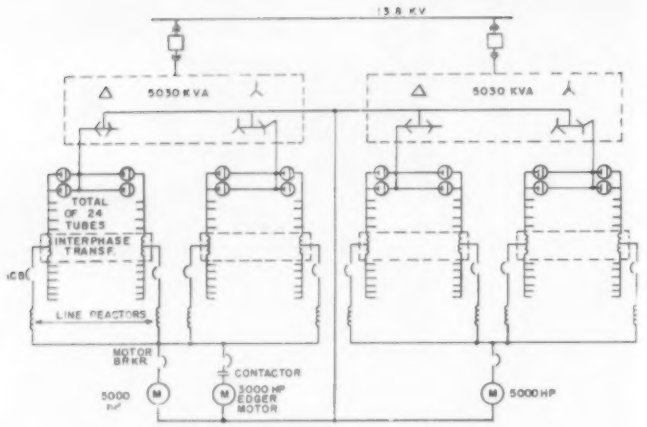


Figure 2 — The edger drive and the main mill drive are both powered from two 2000-kw rectifiers; the edger motor being inserted and removed from the circuit as required by a contactor.

for overload protection. The edger motor armature circuit shows a contactor which is used to disconnect that motor from the rectifier bus when it is not being used to drive the edging mill.

Completely new control was designed to match the rectifier characteristics. The regulating system was synthesized using an electronic computer. It is completely static in nature making use of transistor amplifiers in the circuit areas requiring fast response and magnetic amplifiers in less critical portions of the circuit. Static switching is used for all functions which reverse with the mill. The regulating system was developed as a complete system with the rectifier and was tested along with the rectifier in both model and full scale forms.

A further innovation on this mill is the use of a small ignitron rectifier to excite each of the three motor fields. Transistor amplifiers form the basis for a static motor field regulating system designed specifically for use with the ignitron rectifier exciters.

RECTIFIER-INVERTER OPERATION

Successful operation of the Lukens Steel Co. plate mill has emphasized the fact that characteristics required by reversing hot mill operation can be designed into a rectifier. Such a rectifier must be able to provide motoring power in both directions and accept pumpback power from the motor when deceleration from running speed in either direction is required. This ability to accept pumpback is defined as inversion.

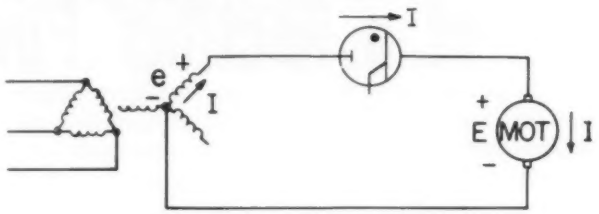
How does a rectifier, by definition a device with unidirectional current flow, accomplish not only motoring power but pumpback in both directions? One definition of rectification states, "rectification is the conversion of alternating current into unidirectional current by means of electric valves." A mercury arc rectifier tube can be said to be an electrical valve. A mercury arc rectifier tube, however, has two significant differences from a simple mechanical valve. It has the ability to block reverse current flow under normal operating conditions and it cannot interrupt current already flowing. Interruption of current flow through the tube is accomplished by applying zero or inverse voltage across the tube. The ignitron can prevent current flow in the normal direction from starting again until it is desired.

An ignitron mercury arc rectifier fires each tube (opens the valve) in sequence so the load is connected to each a-c phase during the time it is most positive in the circuit, and unidirectional current flows through the load. By delaying the firing of a tube so current can flow for just a portion of the time a-c phase voltage is of correct polarity and magnitude, only a portion of the available instantaneous a-c voltage is used to force current through the load and the effect of a lower average d-c voltage is obtained. Thus, controlling the firing point of the tube is an effective way to control the d-c voltage applied to the load.

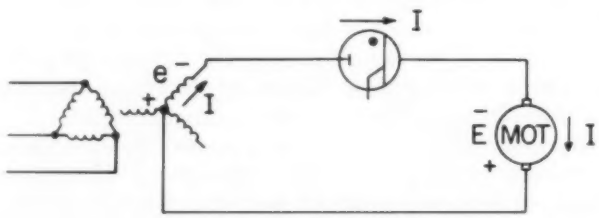
At all times a rectifier operating in the normal sense of rectification is transferring power from an a-c source to a load. The load can be a d-c motor with a cemf. Figure 3 shows a simple rectifier connection.

Assume a cemf type load to be connected through a mercury arc rectifier tube to an a-c voltage source so that the polarity of the d-c cemf is correct to pass current in the normal direction through the tube. A transfer of power from the load to the source can be made by firing the ignitron when the instantaneous a-c voltage is opposing the cemf but the net voltage around the loop produces current from load to the source. This operation is known as inversion. An inverter might be considered as a device which divides up a continuous d-c current into small units and directs each of these units into the proper a-c phase where it will flow in opposition to the voltage in that phase. In this way power is transferred from the d-c source to the a-c source. When the d-c source is a motor this function is also known as pumpback. Figure 3 also shows a simple inverter connection.

Figure 3 — The differences between rectification and inversion circuit conditions are in the polarities of the transformer windings and the motor cemf.



(A) RECTIFICATION



(B) INVERSION

FIG.	TRANSFORMER WINDING		MOTOR	
	POLARITIES	POWER FLOW	POLARITIES	POWER FLOW
(A)	CURRENT FLOW IN DIRECTION OF VOLTAGE POLARITY	POWER FLOW FROM TRANS (RECTIFICATION)	CURRENT FLOW IN OPPOSITION TO MOTOR CEMF POLARITY	POWER FLOW TO MOTOR
(B)	CURRENT FLOW IN OPPOSITION TO VOLTAGE	POWER FLOW TO TRANS (INVERSION)	CURRENT FLOW IN DIRECTION OF MOTOR CEMF	POWER FLOW FROM MOTOR

METHODS OF REVERSAL

Looking again at Figure 3, it can be seen that the difference in circuit conditions between rectification and inversion is in the polarities of the transformer winding and of the d-c motor cemf. The transformer winding voltage is a-c so that it inherently has both plus and minus polarities available. Either of these polarities can be used by simply firing the tube at the right time in the cycle. The motor, however, has either one polarity or the other depending on its field polarity and its direction of rotation. It is apparent that before pumpback of power from a motor to a rectifier can occur, a method of reversing the motor polarity with respect to the rectifier polarity must be arranged.

One simple means of reversing motor polarity is familiar to every electrical engineer in the steel industry. This is the reversal of the motor armature polarity by reversing contactors. All constant potential drives in which contactor reversal is used to plug the drive to a stop or to a reverse direction use this means of reversal. Figure 4 illustrates this form of reversal.

Another simple means of reversal, which is perhaps less familiar, is the reversal of the motor field. This is also illustrated in Figure 4 as being accomplished by reversing a motor field exciter with exciter field reversing contactors. There are many other satisfactory means of accomplishing the motor field reversal. It is, of course, obvious that precautions must be taken in both of the above means of reversals so that they will occur at a time that will not subject the drive system to fault conditions.

Another approach to providing a means of obtaining polarity reversal of the motor with respect to the rectifier is to provide essentially two complete rectifier equipments. These are connected so that current passing through one rectifier equipment in its normal direction will pass through the motor in one direction while current passing through the other rectifier in its normal direction will pass through the motor in the opposite direction. Thus, whenever current is desired in one direction, one rectifier equipment will be used and whenever current is desired in the other direction, the other rectifier equipment will be used. This combination of rectifier equipment can provide for motoring in both the forward and reverse direction as well as pumpback in both the forward and reverse direction without any separate switching circuits.

There are two ways to use the two separate rectifier equipments. The first is illustrated in Figure 5 and is sometimes known as a "cross-connected" circuit. The second makes use of the same transformer windings for both rectifying and inverting functions and is also shown in Figure 5. This connection is known as "back-to-back."

The Lukens plate mill rectifier is a back-to-back connection. The change from motoring to pumpback quadrants occurs smoothly without loss of time. This fact simplified the control and allowed more abundant use to be made of the years of motor-generator set experience.

BACK-TO-BACK RECTIFIER CHARACTERISTICS

Figure 6 shows the theoretical curves for rectifier terminal voltage versus d-c load current of a single

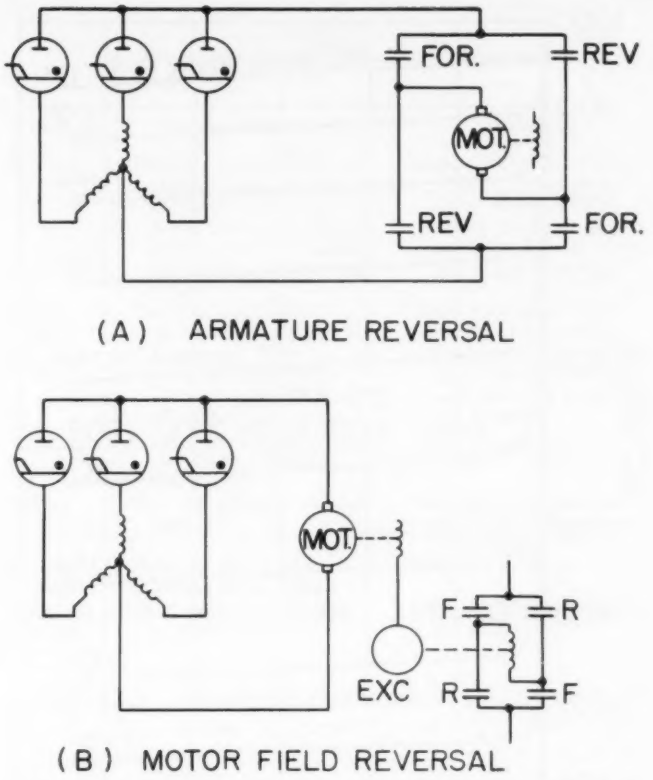
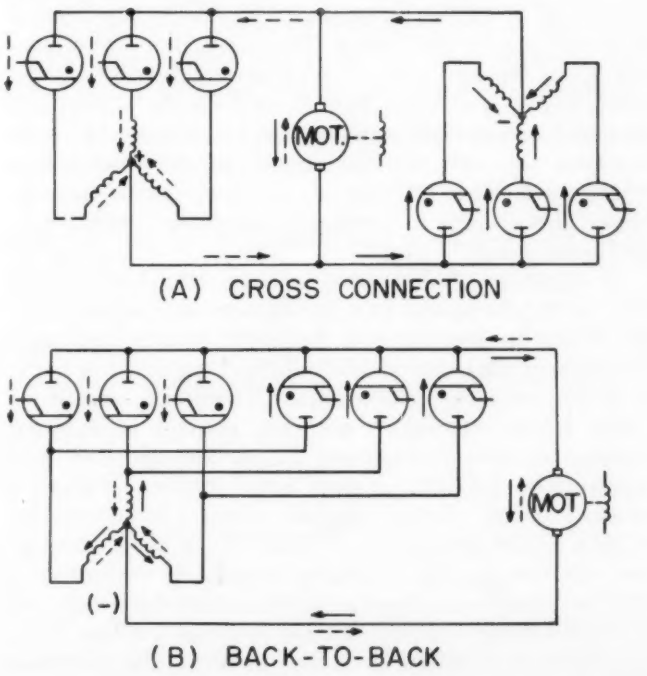


Figure 4 — Reversal of motor polarity can be easily accomplished by either of the illustrated methods.

rectifier. It can be seen that when a rectifier is operating alone as indicated by the curve, a difference in slope occurs near zero load. A brief explanation is that at light loads the rectifier current is discontinuous. When the current is discontinuous, the motor voltage rises above the average voltage of the rectifier and approaches the peak voltage (sum of average and ripple components) produced at the d-c bus. Since the ripple voltage changes with phase control, the light load voltage rise also changes with phase control.

Figure 5 — Connection methods for two separate rectifier equipments are shown.



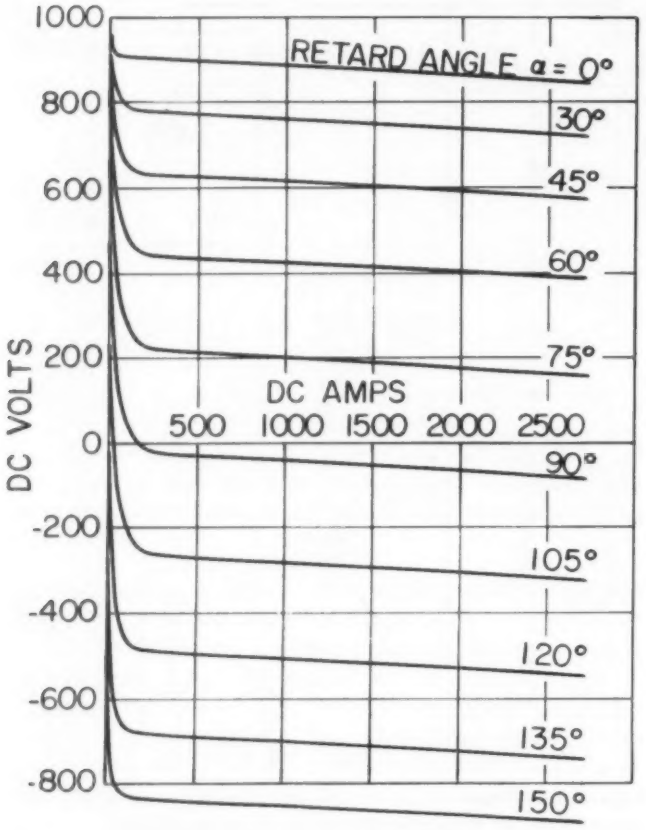


Figure 6 — Discontinuous rectifier current at near zero load causes a difference in the slope of the curve.

One of the problems encountered in transferring from the motoring quadrant to the pumpback quadrant is the discontinuity of the curve encountered at zero load current. The method of solving this problem in use on this plate mill is to preload both rectifiers by circulating some small amount of current between them. When this is done the steep part of the curve near zero amperes partly or totally disappears in the external characteristic of the back-to-back rectifier combination. Three different combination curves are shown in Figure 7. Different amounts of circulating current flow for each of the curves. The regulation curve from inversion through zero current to rectification can be made nearly a straight line. It may on the other hand be most economical to allow some difference to occur between the two rectifier curves so that there is a change in output voltage as the load passes through zero. This change in voltage is sometimes referred to as "dead band."

It might be thought that a large dead band would be a severe handicap in a rectifier-inverter application. It should be remembered, however, that a high gain fast-acting regulator is controlling voltage of the back-to-back rectifier combination. Therefore, except in cases where extremely accurate control is required during the time the current passes through zero, it is permissible to have a dead band present. Figure 8 shows voltage plotted against current for a rectifier with a moderate amount of dead band with the regulator functioning. The regulator completely compensates for the change in voltage as the load passes through zero and the voltage is held essentially constant until the limiting loads are reached in either direction. The curvature up in the inverter direction and down in the rectifier direction at high loads is caused by the current limiting effect of the regulator. Figure 8 is an actual test curve made by connecting one of the actual back-to-back rectifier units for the plate mill to a test generator on a motor-generator set running at constant speed. The rectifier was set at the indicated voltage level and the generator voltage adjusted to produce the desired load current.

PROTECTION REQUIRED

There are several types of faults associated with rectifiers and inverters which are unique to this type of equipment. The common types of failures for which special protection is required are defined below.

Arc back—The failure of a rectifier tube to block the flow of current in a direction opposite to the normal.

Shoot thru—The failure of an inverter to transfer current from one tube to the next at the end of the conducting portion of the cycle.

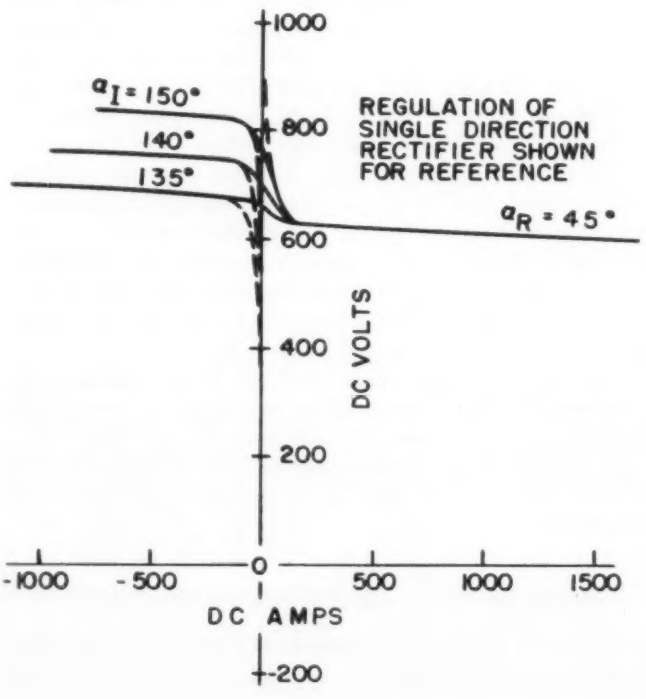
Misfire—The failure of a tube in either a rectifier or inverter to fire.

A-c short circuit—Direct or low impedance connection phase to phase or across one phase of the a-c circuit.

D-c short circuit—Direct or low resistance connection from one polarity to the other in the d-c circuit.

The shoot-thru may be worthy of some special mention since it occurs only in an inverter. The only normal method available for stopping the flow of current through a tube during the inversion cycle is to fire another tube which has a larger voltage differential across it. At maximum d-c voltage, the transfer is made at a time in the a-c voltage pattern when the voltage difference between the d-c motor cemf (in this case the source of current) and the instantaneous phase

Figure 7 — Preloading of the two regulators and circulation of current between them smooths the slope of the curve at zero amp.



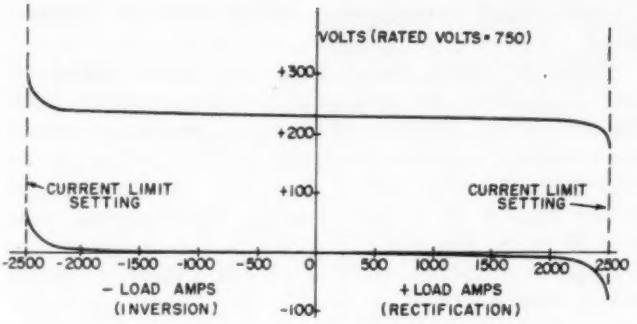


Figure 8 — A high gain fast-acting regulator controls the voltage of the back-to-back rectifier combination.

a-c voltage is increasing for the tube carrying current. At the same time the voltage difference between the motor cemf and the tube to be fired is decreasing. At the point where the voltage difference in the tube circuit which has been carrying current becomes the larger of the two, firing the second tube will no longer cause a current transfer to occur to the new tube. This condition is known as a shoot-thru. Since a voltage inversion across the tube of sufficient time and amount to stop the energy flow through the tube will never occur again, the shoot-thru fault will maintain itself until external action is taken in the circuit to remove it. The peak voltage impressed on the fault is the full d-c voltage of the motor cemf plus the crest of the a-c phase voltage.

Table I lists the various types of rectifier faults mentioned above and the type of protection which must be provided for these faults.

POWER FACTOR

A detailed report is available on the calculation of rectifier power factor[5]*. The simplest concept of rectifier power factor is displacement power factor. Displacement power factor is the ratio of watts to volt-amperes of the fundamental components of a-c voltage and current. The effects of harmonics are neglected. Displacement power factor is related to the angle of displacement of current from voltage. As the rectifier tube is fired later during its positive half-cycle so that current conduction starts later in this half-cycle, the center of gravity of current is displaced in a lagging direction from the center of gravity of voltage. This indicates a lagging power factor.

A good approximation for calculating displacement power factor is

$$\text{Power Factor} = \frac{\text{Load Voltage}}{\text{Edo}}$$

This shows that as the load voltage is reduced by phase control the power factor is reduced. Also, at any fixed phase control angle the power factor decreases with increasing load. Figure 9 illustrates the relation between power factor and d-c voltage for a fixed load current. Also, this figure shows that the per unit reactive energy plotted as a function of per unit d-c voltage becomes a quarter circle for the rectifying quadrant. When it is extended into the inversion quadrant, it becomes a full half-circle.

*Numbers refer to Bibliography at the end of paper.

TABLE I
Rectifier-Inverter Type of Faults and Protection

Type fault	Fault current circuit	Protection
Arc back	Phase-to-phase fault on transformer. Motor connected direct to transformer winding and exposed to double voltage on negative half cycle.	Open all phases of rectifier by preventing firing of tubes or by anode breakers and open d-c circuits with d-c breaker.
Shoot-thru	Phase-to-phase fault on transformer. Motor connected direct through transformer winding so maximum of double voltage applied to IZ drop of circuit during negative half cycle.	Open all phases of inverter by preventing further firing or tubes or by anode breakers and open d-c circuits d-c breaker.
Misfire	One cycle double voltage fault.	Indicate only since fault clears itself if normal firing resumes.
A-c short circuit	Short on one or more phases of a-c circuit.	Open a-c breaker.
D-c short circuit	Short between plus and minus of d-c bus.	Open rectifier and motor d-c breakers.

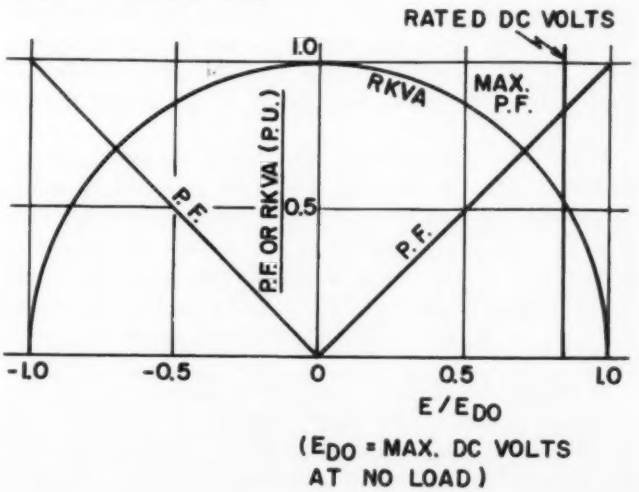
Looking at Figure 9 it can be seen that even at 50 per cent d-c voltage the power factor is poor and reactive power drawn from the line is high. For a reversing hot mill with load currents 200 per cent or higher at reduced voltage, this is a handicap to a rectifier power supply. The plate mill at Lukens steel is normally operated at full voltage when steel is in the mill. The power factor problem was therefore minimized.

IMPROVING RECTIFIER POWER FACTOR

Several rearrangements of rectifier circuits and methods of controlling rectifiers have been considered for reducing the reactive current drawn by rectifiers when operating at reduced voltage. These schemes have been developed and used by European manufacturers and their operation has been well documented.[1,5,6,9]

The particular schemes have been called zero potential anodes, asymmetrical control, and sequence control. Of the three schemes asymmetrical control requires the most additional equipment, has the most complicated control and gives the best power factor correction. Additional interphase transformers operat-

Figure 9 — Reactive kva is a high value even at 50 per cent of maximum voltage.



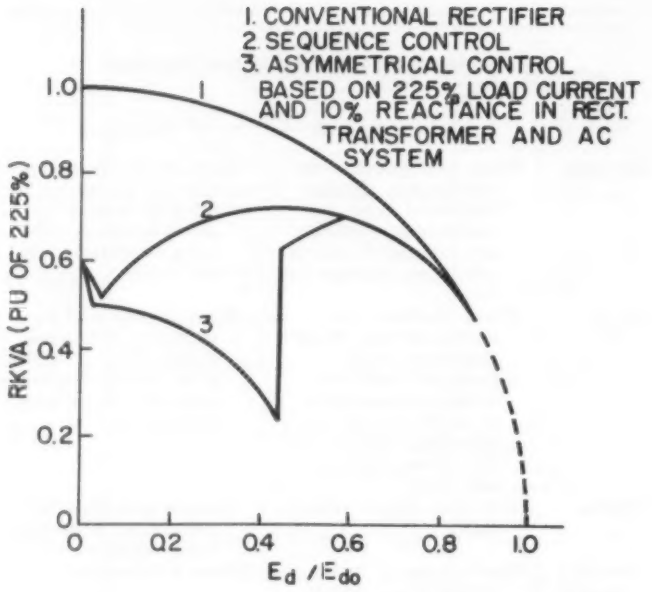


Figure 10 — Reactive power requirements can be reduced by several control methods.

ing at 90 cycle per sec are required which are substantially larger than the normal 180 cycle per sec interphase transformer used with double-wye rectifiers. The additional control complexity is substantial and requires more skillful maintenance. Also the required number of rectifier transformer secondary windings are doubled, unless operation with fewer phases is permissible—say six instead of 12-phase. The relative reactive power drawn by this asymmetrical control as compared with a conventional rectifier is shown in Figure 10.

Zero potential anode circuitry does not require any additional transformers or transformer windings. Additional rectifier tubes, representing approximately one-third of basic capacity, are required along with extra equipment for their excitation and control. The relative improvement in reactive power requirements is the smallest of the three schemes.

Sequence control requires no additional transformer or rectifier tubes and a very minimum of additional control equipment. As shown in Figure 10 the improvement in reactive power requirements is just as good as asymmetrical control for the operating range between half-voltage and full voltage. If the arrangement of motors lend themselves to operation in series, or if higher voltage (say 1200-volt) motors can be economically justified then this scheme looks the most attractive. As with asymmetrical control, the number of phases of a rectifier may have to be reduced—say from 12 to six phase.

With sequence control, and assuming operation at half voltage, the reactive would be reduced to about 75 per cent of that required by a conventional rectifier. If peak torque is required at stand-still, the reduction in reactive would be to about 50 per cent. While the improvement at standstill is very impressive, this would seem to be a very infrequently used operating condition.

It should be clearly understood that in all of these methods power factor improvement is achieved only at reduced voltage. The effect of the rectifier upon the a-c system voltage when operating at rated voltage is a fundamental consideration which must be investigated.

Moreover static shunt capacitor banks could be used to improve the average power factor drawn from the a-c system. They are effective in absorbing some of the harmonic currents produced by the rectifier. However, they have no effect upon the voltage dips or flicker caused by impact loading. Synchronous condensers with electronic regulators can be made to respond in about one-tenth of a sec and thereby greatly reduce the duration of the flicker. Other aufomatic electronically controlled reactive power compensation methods that respond in less than one-half cycle may also be used to reduce or eliminate voltage fluctuations caused by the heavy reactive power swings resulting from impact loading.

In applications where voltage dip is a problem, the economic considerations will determine the best approach. These alternatives should be considered: stiffen the a-c system, add kvar control, use sequence control on rectifier, use flywheel motor-generator set.

PERFORMANCE

In many ways designing performance into a rectifier drive is a delightful experience to the control designer. A rectifier with an electronic firing circuit basically responds with almost no time delay to a signal circuit calling for a change in the rectifier output voltage. The output voltage builds up exponentially for a magnetic firing circuit and instantaneously for an electronic firing circuit. There are, of course, some complications in this concept but inherently the rectifier offers many attractive possibilities.

One of the by-products of the rectifier's inherent response is the fact that the control regulator design is less inhibited by time constants and other characteristics of components over which the control designer has no control. The design approach used for this plate mill was to start with a theoretical regulating system which was nothing more than a series of mathematical equations plugged into an electronic differential analyzer. Modifications were then made to give the performance characteristics sought by the designer. Up to this point the practical aspects of design were ignored and the theoretical mathematical approach followed. After known components such as the rectifier itself were inserted in place of the theoretical blocks, it was discovered that it was quite easy to simulate the remainder of the theoretical circuit with actual components. Time constants, for instance, could be manufactured by means of a simple capacitive or inductive circuit using small, easy to obtain components. Gains could be produced with no time constant involved, if desired, by means of transistor amplifier circuits. All of these techniques were found to be compatible to the rectifier since it demanded a very low power level input to control its output voltage.

What all of this means in terms of performance is that the response and the gain of the various regulating functions can be established so that there is no conflict between functions. This in turn means that drive performance is predictable as well as accurate and fast.

Another by-product of the electronic firing circuits used for this mill is a linear relation between voltage

output of the rectifier and input excitation. Such a linear relationship when compared with the nonlinear excitation curves of magnetic firing circuits means an easier job for the control designer. Necessary gains with stable response are easier to obtain.

The important electrical functions which are controlled by the regulator are voltage and current of the rectifier. The voltage control was set for an adequate response rate needed to control voltage during the time that the slab is entering the mill and during voltage reversals. In terms of control response the voltage reversal is slow and this did not offer any unusual problems.

For the period during which the slab was entering the mill, current controls became important. Good motor commutation demands that a limit be set upon maximum peak amp which can be drawn by a particular load. This limit varies with motor field strength. For many years current limit circuits have been provided to protect motors against more than their allowable peak amp. These current limit circuits have generally worked to strengthen the motor field, thereby providing additional torque to finish a pass and get the slab through the mill. This same feature is available in this mill but with an improved response due to the use of electronic exciters on the motor fields. Here again, as for the main rectifiers, the field excitation rectifier time constant allows great freedom to the control designer in creating an ideal system.

In addition to the conventional current limit system working on motor field, this mill is provided with a current limit system working on rectifier voltage. Rectifier voltage is reduced when the motor current becomes too high with the field already at full strength. Testing experience in the factory and during rolling conditions have indicated that the rectifier is very successful in providing this function. Current peaks have been clipped off with no appreciable overshoot and the motor stalled with full current available. While it is not desirable to stall the mill, this current limit makes available not only the maximum capacity of the motor before stalling but releases the stored energy of the motors and the mill rotating parts to provide all available energy to finish a pass. The current limit feature also prevents the mill circuit breakers from tripping thereby reducing the maintenance effort required.

To provide best mill motor commutation it is not only necessary to limit the peak amp but also in some cases to limit the rate of change of current occurring as the current builds up to its peak amp. In the past, this limit has demanded such fast response that it has not been used for this type of mill when powered by motor-generator sets with conventional excitation systems. The theoretical study of the regulating system showed that it was possible to control rate of change of current with a rectifier system and this function was added to the control. It has a limited usefulness due to the fact that when current rate is limited too severely the voltage must change to a larger degree. This is undesirable and a compromise between these two factors must be reached. The fact, however, that the rate of change of current can be limited with the rectifier system illustrates the inherent capabilities of such a system.

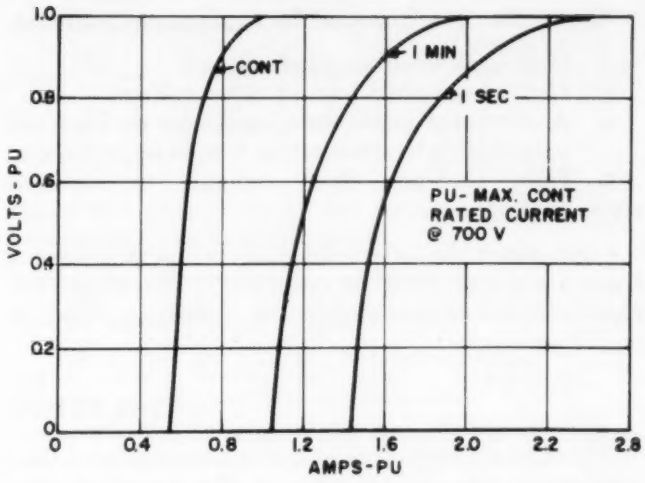


Figure 11 — Rectifiers are characteristically poor in handling peak loads at reduced voltages.

LOADS FOR A REVERSING RECTIFIER

The experience gained from this large installation and from other installations of small reversing rectifiers as well as experience gained from rectifier installations on unidirectional mills has emphasized the fact long known to designers of rectifier equipment that there is little reason to believe that rectifiers cannot do every job now accomplished by generators. However, special design precautions which may be needed or additional equipment which may be involved can conceivably make the rectifier uneconomical. How, then, can one decide where the best applications of reversing rectifiers can be found?

Figure 11 shows curves of allowable peak load amp vs d-c voltage for an ignitron mercury arc rectifier tube. These are typical curves for frequently repeated loads of one sec and one min durations as well as continuous loads and are calculated by assuming a uniform conservative arc-back rate for all values of voltage. It can be seen that while the rectifier can handle high peaks with ease at rated voltage, it finds high peak loads at low voltages inherently difficult. Although the addition of components such as commutating reactors can improve the ability of the rectifier at reduced voltages, these curves correctly indicate that the rectifier likes best to operate at rated voltage. Reference again to Figure 9 is a reminder that in addition to the rectifier's natural aversion to high peak loads at low voltages, the effect on the power system must be considered if the rectifier represents a large portion of the load on the system. These two factors are the sign posts which indicate a need for careful analysis of the duty cycle where reduced voltage operation is involved.

Another factor of rectifier application which should be considered is its ability to provide with ease the control functions required. Figure 7 indicates that at light loads there may be some problems with a rectifier due to the change in the slope of the regulation curve. While this is correct, this problem can be minimized or eliminated by proper design. In all other aspects of controllability the rectifier is excellent. It rates high in ability to provide a wide range of functions with good response and accuracy.

The rectifier is a "natural" for applications requiring:

1. High peak loads at rated voltage.
2. Continuous rated load at rated voltage.
3. Acceleration or deceleration under no load and with moderate accelerating torque requirements.
4. High accuracy, fast response, or versatile control.

Other power converters obviously compete in some of these areas and must be considered. Providing their characteristics are acceptable, the comparison becomes one of economics.

THE FUTURE

Although rectifiers are not new, the extension of their application into a new area of the American steel industry causes one to wonder—what of the future? Is the rectifier here to stay as a power supply for a reversing drive? There can be no question on this point. The rectifier will be used in more and more applications most of which will be good but perhaps a few of which may be marginal. In some cases, the answer will be clear since there will be no device but a rectifier which is capable of doing a particular job. In most cases, the answer will be obtained by a careful engineering and economic comparison of the various power supplies available.

The reversing rectifier is an exceedingly useful tool. It should be considered wherever reversing drive systems appear and evaluated on its merits.

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APPENDIX A

EXPLANATION OF RECTIFIER-INVERTER OPERATION

Power rectifiers have been used for many years and their operation is well-understood. Inverter operation is not new, but its application to motor drives is being extended rapidly. A simple underlying rule for both rectifier and inverter operation follows: *Providing adequate cathode electron emission is available, and these electrons are not blocked by negative grids, only the anode or anodes most positive in the circuit will conduct current.*

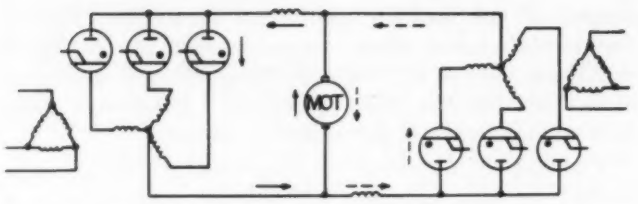


Figure 12 — Two 3-phase rectifier-inverters in cross connection.

In order to explain the operating principles of the rectifier-inverter, we will use a simple three phase circuit, cross-connected (Figure 12). Examination of the circuit shows there are two rectifier-inverters which except for their polarity in the circuit are exact duplicates. The power supply will be assumed to be the same for the two units. The flow is always in the same direction in a particular rectifier-inverter unit but can be in either direction through the d-c motor depending on which rectifier-inverter is conducting. It can be seen that current can also flow from one rectifier-inverter to the other. The d-c reactors are in the circuit to reduce ripple current through the motor and to control circulating currents between the rectifier-inverter units. The discussion will ignore the ripple and circulating currents.

Rectifier operation—In order to explain rectifier and inverter operation motor polarity will be assumed such that the forward rectifier-inverter unit will act as the rectifier and the reverse unit will act as the inverter. Figure 13 shows the a-c positive half-waves from the three phases of the power supply. Since the three phases are connected to the three ignitron tubes, the positive half-waves are applied in the correct sequence to the tubes. Figure 13 considers the ideal case with no circuit reactance and firing at full advance. In this case current transfer from tube to tube would be instantaneous and each rectifier device would conduct

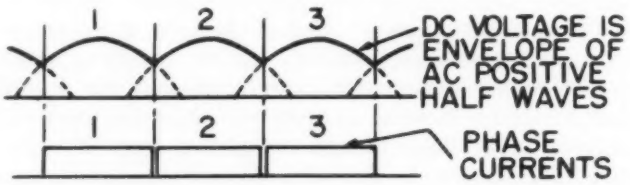


Figure 13— Phase voltages and currents for a rectifier without reactance or phase control.

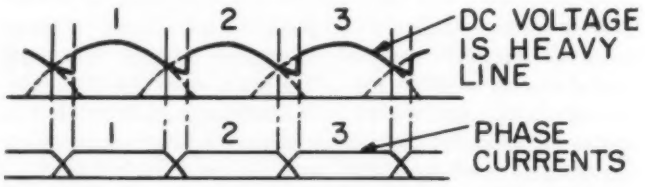
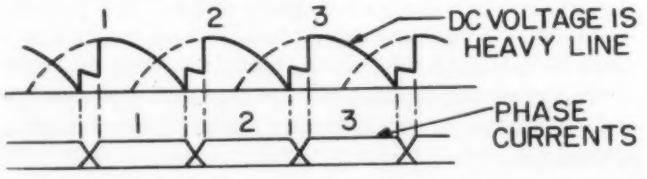


Figure 14 — Phase voltages and currents for a rectifier with reactance but no phase control.

Figure 15 — Phase voltages and currents for a rectifier with reactance and phase control.



direct current between the intersection of its positive half-wave of voltage with the preceding and succeeding half-waves. Conduction periods would be 120 electrical degrees because each phase voltage is more positive than any other for such an interval.

Practical circuits have reactance so current transfer cannot be instantaneous. Figure 14 shows such a case. Current transfer from one tube to another is known as commutation. During the commutating period the two phase voltages must be equal since they are connected directly together and the d-c voltage is equal to the average of the two phase voltages. The average d-c voltage is lower in Figure 14 than in Figure 13 due to the effect of the notch being removed from the voltage wave during the commutating period. The length of the commutating period is increased as the reactance becomes higher. Therefore, the d-c voltage will be lower in those circuits having higher reactance.

In the ignitron mercury-arc rectifier the method of reducing the voltage during operation is to delay the firing of a tube which delays the instant of cathode emission. As long as there is no cathode emission there can be no current conduction even though the phase voltage of the tube is the most positive. The action which delays the firing of the tube is known as phase control and is illustrated in Figure 15. It can now be seen that the notches removed from the a-c voltage are deeper and cover more area than those in Figure 14. It is therefore obvious that the average d-c voltage is now lower. Many methods are used for phase control and consequently the control of d-c voltage.

Inverter operation—To understand inverter operation we must first recognize that a source of d-c voltage must be available in the circuit. In this case the source of d-c voltage is the motor cemf. As is the case in any motor pumping back current into a power supply the motor cemf must be opposed by the power supply voltage.

Current can flow in only one direction through an ignitron mercury-arc rectifier tube. Let the half-cycle of a-c transformer voltage which is of the correct polarity to force current through the ignitron in the normal direction be defined as the positive half-cycle. This is the normal convention for rectification. The negative half-cycle then is of the proper polarity to oppose the flow of current through the ignitron. With an external source of d-c voltage forcing current through the rectifier tube, firing the tube during the negative half-cycle makes certain the a-c power source voltage opposes current flow; and the conditions are met for the pumpback of power from the d-c external source (the motor) to the a-c source. Figure 16 shows the case when a tube is fired during the negative half-cycle, assuming a system with no reactance. For this case, with no phase control, we can assume instantaneous current commutation at exactly the time of intersection of the successive negative half-waves. The action of the inverter, then, is to divide the d-c power into blocks, sort the blocks out and direct them into the correct transformer secondary at the right time to deliver a-c power to the system.

An important item to understand in inverter operation is that commutation must be completed before the intersection of the negative half-waves of the phase carrying current and the phase which is next to

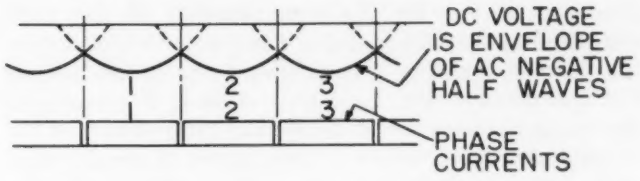


Figure 16 — Phase voltages and currents for an inverter without reactance or phase control.

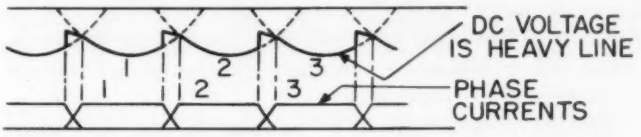


Figure 17 — Phase voltages and currents for an inverter with reactance and minimum phase control.

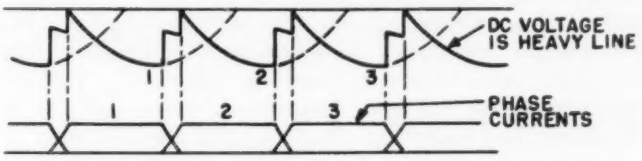


Figure 18 — Phase voltages and currents for an inverter with reactance and additional phase control.

carry current. Figure 17 shows this for the actual circuit with reactance. If current were allowed to flow in any phase after its voltage intersection with that of its successor, the initial phase could never transfer current to its successor, since the voltage difference between the initial phase and the d-c source (motor cemf) is greater than the voltage difference between the successive phase and the d-c source. The failure of the transfer of current is considered a commutation failure and inversion would cease. As the phase voltage passes through zero and becomes positive the inverter counter d-c voltage disappears completely causing the inverter not only to short circuit both the rectifier and the d-c motor, but to contribute its positive half-cycle of voltage to the fault.

Consider again Figure 17 the case of a circuit with reactance and no phase control. If current commutation is to be complete in this case by the intersection of the phase voltage waves, the start of commutation must occur sometime previous to this point. This means that the succeeding tube must be fired ahead of the intersecting point by the amount of time needed for commutation. Phase control is therefore seen to be mandatory in inverter operation.

Comparing Figure 17 with Figure 14 shows the inverter firing point of a tube connected to a given phase voltage is delayed somewhere around 120 to 150 electrical degrees beyond the point of firing for full rectification voltage. Generally the angle of phase control for rectifiers is stated in terms of retard, zero angle being defined as the firing of the tube at the positive half-wave intersections. Inverter angle of phase control is more frequently referred to as an angle of advance where zero phase advance would be defined as the start of conduction at the negative half-wave intersections.

If the angle of advance of the inverter is just sufficient to complete current commutation before the intersection of the negative half-wave, the d-c voltage wave will be the heavy black envelope of the a-c wave with a

notch taken out for the commutation. If the tube were fired at the same point in the reactanceless circuit, the current transfer would have been instantaneous and the notch would have been deeper. For example, the firing of phase 2 just before the intersection of the voltage waves of phase 1 and phase 2 would have caused the d-c instantaneous voltage to immediately become that of phase 2. This would represent a reduction in the d-c inversion counter voltage. Therefore, it can be seen that for inverter operation, reactance in the circuit actually increases the d-c voltage above a value which would be obtained for the same angle of advance with no reactance.

For inverter operation to be reliable, the commutation must always be successful. Consider Figure 18 here a more liberal angle of advance is provided than in Figure 17. Now the commutation is clearly complete before the intersection of the negative half-waves, providing a margin for deionization of the tube which has just been carrying current before its voltage again becomes the most positive in the circuit. It is apparent, however, that introducing a margin angle in inverter firing again reduces the available counter d-c voltage. In order to control the flow of current from the motor back through the inverter into the a-c system, the average d-c counter voltage of the inverter is controlled by the angle of advance of the firing point. Control circuits, such as current limit, can then work very easily through the phase control system of the rectifier-inverter.

Motor reversal—To this point we have discussed the case where one rectifier-inverter unit is being used as a rectifier and the other as an inverter. During this discussion it has been assumed that the unit being used as a rectifier is fired during its positive half-cycles of a-c voltage and that the unit being used as an inverter is fired during its negative half-cycle of voltage. Under these conditions, the rectifier is of such polarity to provide motoring power to the motor and the inverter is of such polarity to accept pumpback power from the motor. Since it is also desired to reverse the motor by reversing its armature voltage, the polarities of both the rectifier and inverter must be reversed. The firing angle of the forward rectifier-inverter, which has been acting as a rectifier, is retarded to the point where it is firing during the negative half-cycle and at the same time the firing point of the reverse unit, which has been acting as an inverter, is advanced to the point where it is firing in the positive half-cycle of its voltage. The two units will interchange functions and the motor polarity will be reversed. That is, the unit which has been acting as an inverter will now begin to rectify and supply motoring power in the reverse direction while the unit which has been acting as a rectifier will be available to accept pumpback power from the reverse direction. It can be seen that when the motor is operating in the forward direction the rectifier-inverter unit designated as forward will be able to supply d-c power to the motor taking such power from the a-c system. It will also be seen that when it is desired to return power from the motor to the a-c system (pumpback) this power will be transferred through the unit designated as the reverse rectifier-inverter. On the other hand, when the motor is operating in the reverse direction, it can be seen that the power is supplied from the a-c line through the unit designated as the reverse rectifier-inverter and power is returned to the line through the unit designated as the forward rectifier-inverter. Thus, with two complete rectifier-inverter units connected in polarity opposition as indicated by the cross connection of Figure 12, a power supply is available which can provide motoring power forward and reverse or accept pumpback power from either the forward or reverse directions. The motor can now be operated normally in all four quadrants.

Discussion

PRESENTED BY

G. M. ZINS, Manager, Ignitron Rectifier Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

C. E. RETTIG, Manager, Rectifier Circuit Development, General Electric Co., Philadelphia, Pa.

G. M. Zins: We have recently been investigating the four methods of power factor improvement, which are: (1) the shunting tube method, (2) the pulse firing method, (3) the asymmetrical firing method, and (4) the series converter method. At the present time the asymmetrical firing method looks promising but, as the authors point out, this involves some very complicated control and there are many problems to be solved to make this method commercially feasible.

C. E. Rettig: The pulse commutation, or pulse firing method, has been of considerable technical interest, but we do not believe it to be economical for a large reversing drive. The automatic electronically controlled reactive compensation method mentioned in our paper appears less expensive and offers additional benefits to a user in the form of system voltage control and reactive current compensation. ▲

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OPEN COIL PROCESS

Shows Way to Gas Alloying

Exciting possibilities are indicated by the new open coil gas alloying process. It may provide a tool for making the thin tinplate of the future; it may provide a means to use ordinary bessemer steel for flat products and it will provide a means for satisfying exacting metallurgical requirements.

by J. ARNOLD, Manager of Engineering and New Products,
Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

A RECENT development in annealing, the open coil annealing system now enables the operator to chemically change and refine flat rolled steel. The system incorporates a method of loose winding cold rolled strip in a vertical position, with each wrap of the coil equally spaced in a vertical plane. The medium used for spacing the coil wraps is a nylon string, or a metal tape. For comparison purposes, Figure 1 shows a tight wound coil on the right and a loose wound coil at the left. The spacing between the wraps in the loose wound coil is slightly exaggerated so it can be clearly shown. These model coils represent an average coil of 24 in. inside diameter, 66 in. outside diameter, and any given strip width, with the coil on the left hand side loose coiled to an outside diameter of 114 in.

The operation sequence of the coiling system starts with a cold rolled tight wound coil being placed on the pay-off table for the loose winding operation. A string is then inserted in the coil to be loose wound. The top of the strip has been slit for a depth of 1 in. and approximately 5 in. in length for easy insertion of the string.

Figure 2 shows the loose coiling operation. The two large assemblies in the center are the bridle roll assemblies. These are used for the tight winding operation after the material is annealed. The procedure shows the strip moving from the mandrel on the left to the loose table mandrel on the right. When the coil is to be rewound the direction of the coil is through the loop control, the vertical guide rolls immediately to the right of the tension rolls, in and around the tension rolls, and rewound on the tight coil table.

Figure 3 shows the completion of loose coiling and the operator removing the nylon string from the open coil. In Figure 4 the open coil is being removed from the open coil table. This is also a very good picture of the special magnet developed for handling open coils. The markings on the magnet arms and on the open coil table are used to center the coil onto the table after annealing.

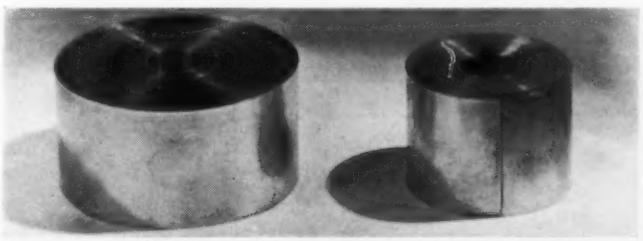


Figure 1 — Opening coil allows intimate gas contact.

Figure 2 — Coil is opened by recoiling with a string to set the spacing.

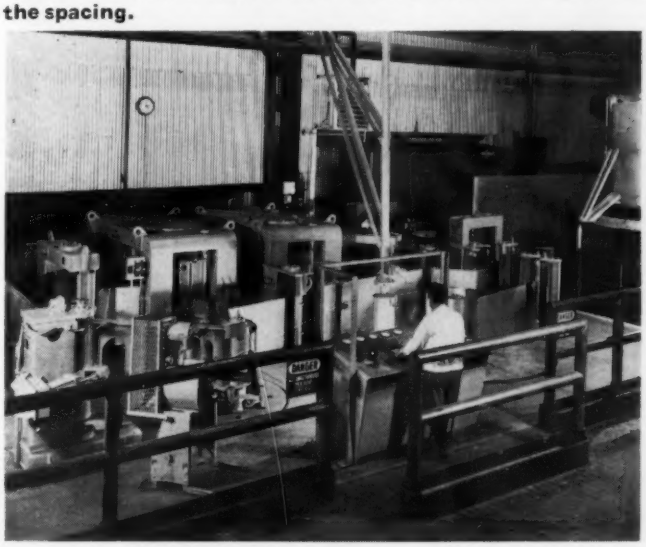


Figure 3 — Separating string is made of nylon and removed after coiling.

Figure 4 — It was necessary to develop a special magnet in order to properly handle the loose coils and maintain spacing.

Figure 5 shows the open coil on the annealing base assembly with the inner cover being set in place. This stainless steel alloy inner cover utilizes liquid seals to make the base assembly completely gastight. This is required to get the maximum control of the atmosphere gases. Figure 6 shows the furnace in place under operating conditions. Also shown is the method of exhausting flue gases if so desired.

The annealed coil is next removed from the base assembly, placed on the open coil table and recoiled to a tight condition.

Figure 7 is the plan view of the two open coil systems—one for sheet, the other for tinplate. The one on the right is for tinplate and the type illustrated so far. The course of the coil during the loose wind operation can be followed through the guide rolls, through the loop control assembly and onto the open coil table. On this same diagram one can also see the course of the strip as it is taken from the open coil table, through the loop control, through the edge guides, over the double set of bridle rolls, around the deflector roll, and tight coiled on the tight coil table.

The plan view on the left shows the open coil system for sheet coils. This is a somewhat more compact unit, as only one tension drum and idler roll is required to handle the heavier gage strip material. A different method of obtaining loop control is also shown. This requires a double assembly. The tight coil, as it is brought to the department, often has rolling oils on the surface. One set of loop control rolls is used for the open coiling and a separate set is moved into place for tight winding. With this method, oil contamination of the annealed coil surface is prevented. The course of the strip for recoiling is as follows: from the open coil table, around the loop control, through the edge guides, around the large tension

Figure 5 — Liquid seals are used on inner cover.

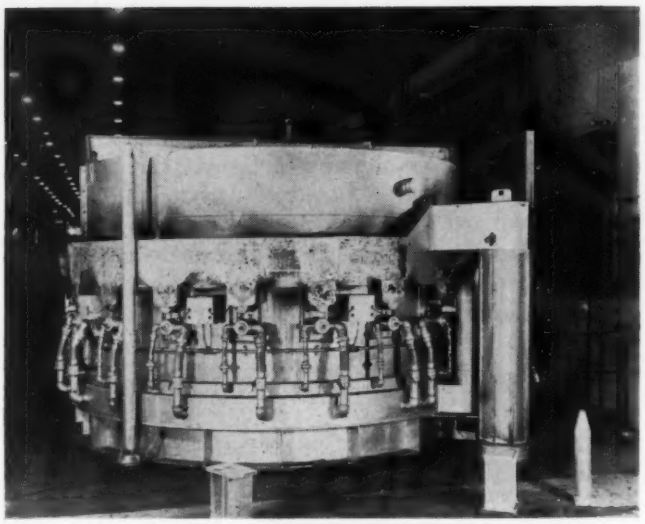


Figure 6 — Furnace is now ready for treating operation.

drum onto the tight coil table. For heavy gages the tension is controlled by the narrow-body snubber roll. For lighter gages the combination of the extra idler roll and the narrow-body snubber roll are used.

To this point the open coil annealing system has been reviewed. The gas alloying phase will next be discussed.

ADVANTAGES OF OPEN COILING

At the top of Figure 8 is a graphic illustration of the type of coil annealed in standard annealing furnaces. This coil is so tightly wrapped the heat for annealing can be absorbed by the surface area of the sides, top and bottom; by radiation, convection and conduction as the gases travel over the coil for heating purposes. The very nature of this tightness excludes the possibility of atmosphere gases penetrating any more than slightly into the edges at the top and bottom of the coil.

The bottom section of this diagram shows the open coil and the intimate contact the heated gases have with all of the coil surface. This intimate contact of gases with the surface of the steel not only means the gases cover all of the coil surface but the temperature difference between the steel and the atmosphere gases is within the readable tolerances of the average furnace thermocouple.

This close contact of the heated atmosphere gases is an outstanding feature of the open coil system, particularly from a gas alloying standpoint. This means any gas equilibrium reaction that exists within the area of the steel is at the correct temperature level for the constituents of the atmosphere gas and the interstitials in the steel. An interstitial is any component of the steel that will exist in both the solid and gaseous form. The two interstitials we are interested in are carbon and nitrogen.

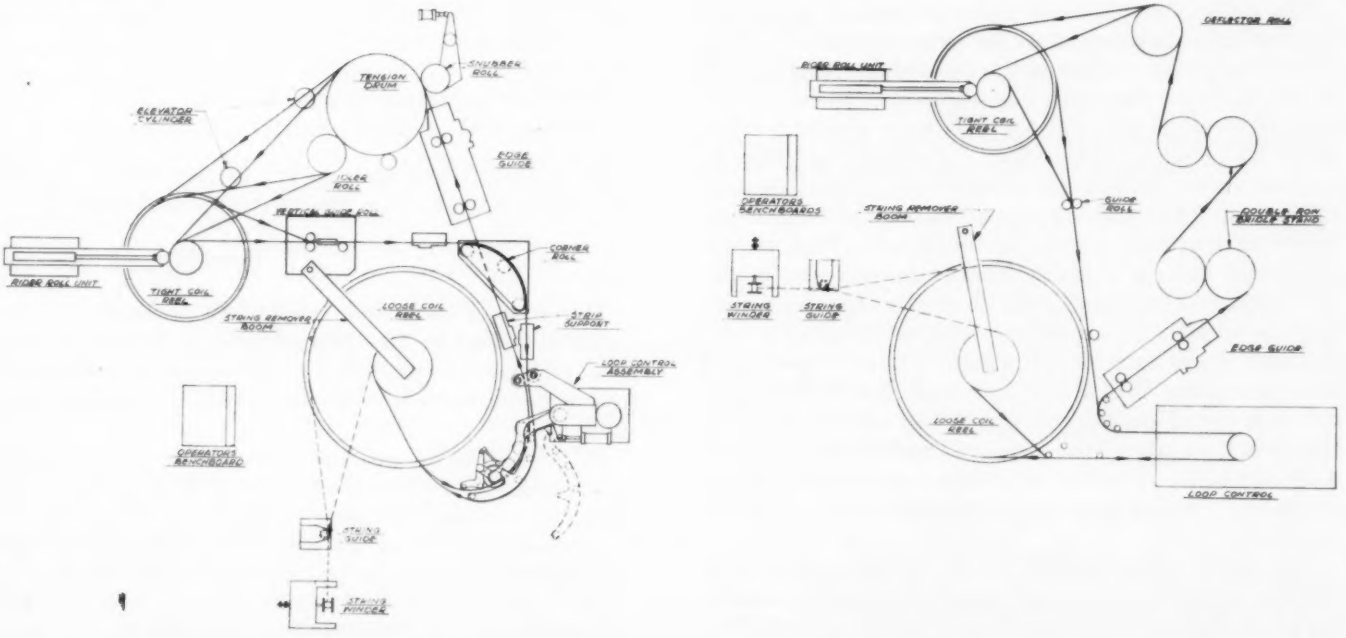
Figure 9 shows a cutaway view of one heating system. This depicts a method of passing very large volumes of gases across the surface of an inner cover, vertically past radiant heater tubes and vertically downward across all of the exposed coil surface. This system is engineered to have many gas changes per minute across the surface of the coil. It also incorporates a method of controlling constant flows of the special atmosphere gases to and from the base assembly.

IMPORTANCE OF GAS ALLOYING

At this point gas alloying should be defined more clearly. This system, with the use of special atmosphere gases during the annealing cycle, allows control of the interstitials of the steel to a point where it is possible to:

1. Produce a nonaging rimmed steel by reducing the percentage of carbon to 0.001 and nitrogen to 0.0004 per cent.
2. Reduce the carbon and nitrogen in rimmed steel to produce an annealed product suitable for enamel iron.
3. Control carbon content and grain structure in rimmed steel to produce a material suitable for XDD galvanized stock.

Figure 7 — Open coil system varies if sheet or tinplate is to be treated. System on left is used for sheet, and that on right for tinplate.



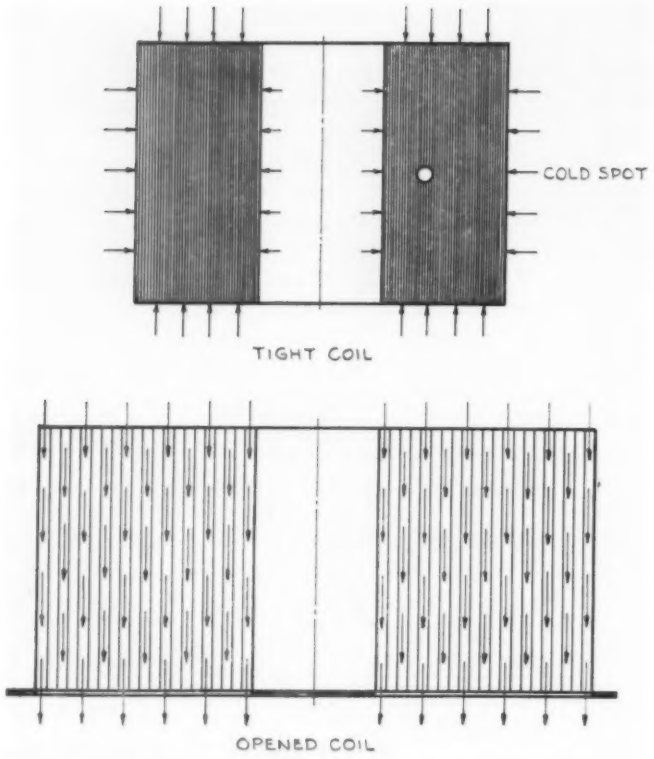


Figure 8 — Opening the coil also gives quicker heating.

4. Reduce the carbon and nitrogen in rimmed steels to produce a low carbon strip as a substitute for low grade silicon sheet for motor laminations.

5. Reduce the carbon content of silicon sheet to improve electrical characteristics of silicon sheet for motor and transformer laminations. Desirable surface conditions can also be obtained with this system.

6. Restore carbon to strip to desired depth and concentration.

7. Restore nitrogen to strip surface in the form of nitrides to any depth required.

There are many other concepts of what can be accomplished with this system and more will develop. However, for the present, the explanation of the seven listed processes will be discussed.

The initial conception of a process such as gas alloying is often as interesting as the process itself. The first indication of this phenomena arose while setting up test cycles to prove the open coil annealing process. Four coils of steel of identical analysis were picked for the tests. Two coils were annealed in the open coil process. Two coils were annealed in standard bell type annealing equipment. On checking the metallurgical results the following data were correlated—Rockwell, Olsen, tensile and yield. Also a chemical check analysis was made. The open coil annealed steel showed improved metallurgical results. The chemical analysis revealed a considerably lower carbon and nitrogen content, leading to the assumption that a different type of steel was used for each test. However, on completely examining all of the data, it was found the improved metallurgical results were due to the reduction of carbon and nitrogen during annealing. Further test cycles substantiated the original data.

The above data brought to mind the problem of surface contamination of carbonaceous gas when annealing black plate (tinplate material). For this reason a test cycle for annealing tinplate was set up using bottled H_2N_2 gas of approximately 5 per cent H_2 with a -40 degree dew point. A graph of this cycle is shown in Figure 10. This cycle indicated a percentage build-up of approximately 1.2 CO, 0.3 CO_2 and a 1.5 max, 0.5 min H_2O during soak. From many such tests, the indications were that controlled removal of carbon and nitrogen could be realized with proper control of atmospheres.

A study of the action of the atmosphere gas components on steel at elevated temperatures shows the following reactions take place.

O_2

Reacts with iron in steel to produce iron oxide (scaling).

$$2Fe + O_2 = 2FeO$$

Reacts with carbon in steel to lower its concentration (decarburizing).

$$2Fe_3C + O_2 = 6Fe + 2CO$$

N_2

Nonreactive in generated atmosphere gases.

Reactive when dissociated from NH_3.

CO_2

Reacts with iron to produce iron oxide.

$$Fe + CO_2 = FeO + CO$$

Reacts with carbon to lower carbon content (decarburizing).

$$Fe_3C + CO_2 = 3Fe + 2CO$$

CO

Reacts slowly with iron to form iron carbide (carburizing).

$$3Fe + 2CO = Fe_3C + CO_2$$

Breaks down at low temperature to form CO_2 and free carbon (soot).

$$2CO = CO_2 + C$$

H_2

Reacts with iron oxide to reduce it to iron.

$$FeO + H_2 = Fe + H_2O$$

May be absorbed by high carbon steels. Nondecarburizing if dehydrated.

H_2O

Reacts with iron to form iron oxide.

$$Fe + H_2O = FeO + H_2$$

Reacts with carbon in steel (decarburizing).

$$Fe_3C + H_2O = 3Fe + CO + H_2$$

Hydrocarbons

Definitely carburizing.

$$3Fe + CH_4 = Fe_3C + 2H_2$$

At this point written data for the removal of carbon and nitrogen from steels was correlated and studied.

LITERATURE REVIEW

The first information uncovered pertains to the Gensamer process. This process has the following eight patent claims for the removal of carbon and nitrogen from rimmed steels to effect the production of nonaging steels[1]:*

1. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than that to produce large grains but high enough to reduce the yield point and for a time sufficiently long

* Numbers refer to Bibliography at end of article.

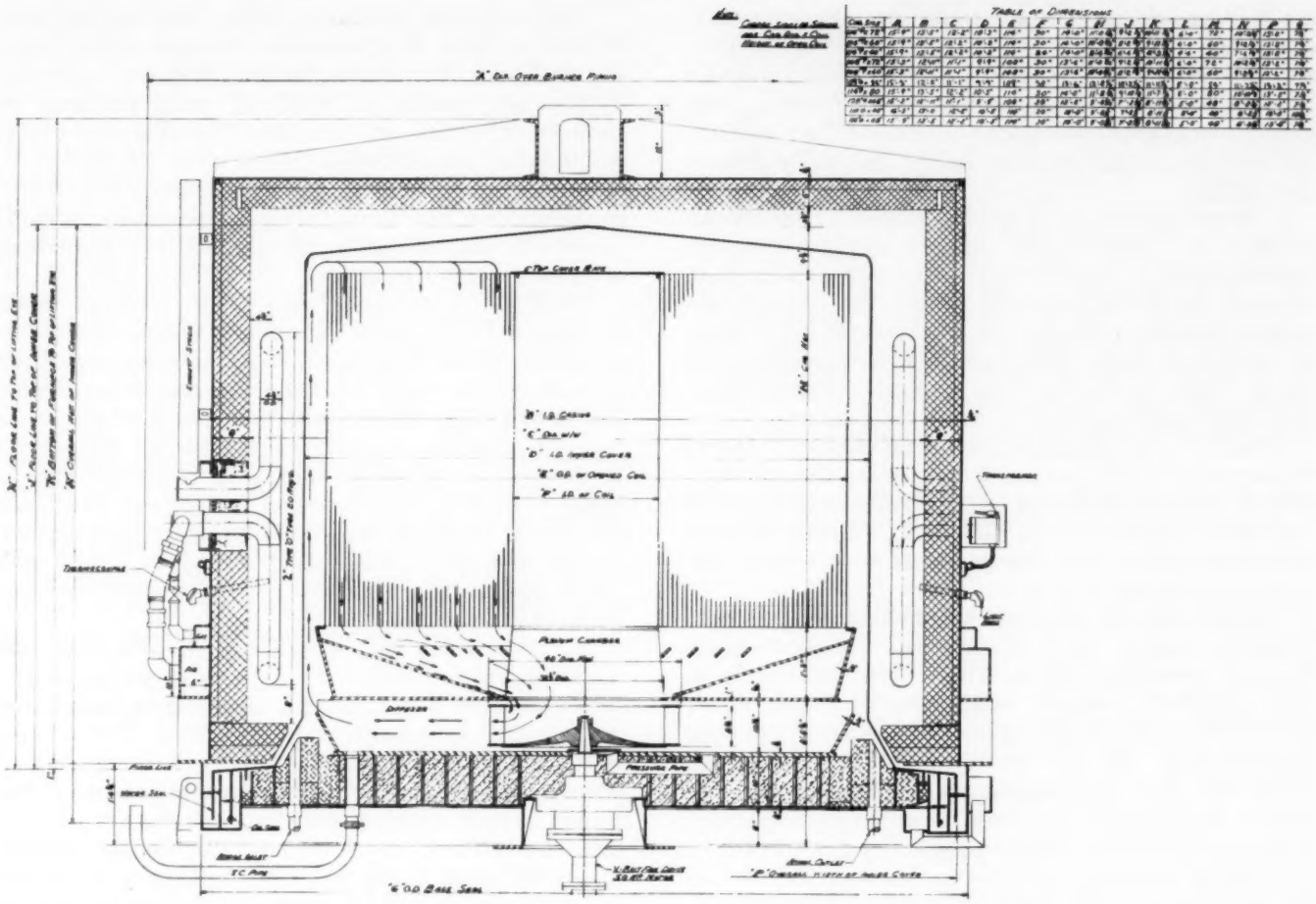


Figure 9 — Cross section through open coil annealing furnace shows methods for controlling gas flows.

to practically eliminate the yield point.

2. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time sufficiently long to practically eliminate the yield point said atmosphere containing water vapor in an amount less than causes material scaling but sufficient to materially reduce said time as compared to its length when said atmosphere does not contain said water vapor.

3. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere volumetrically containing from 5 per cent water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time long enough to materially reduce the yield point.

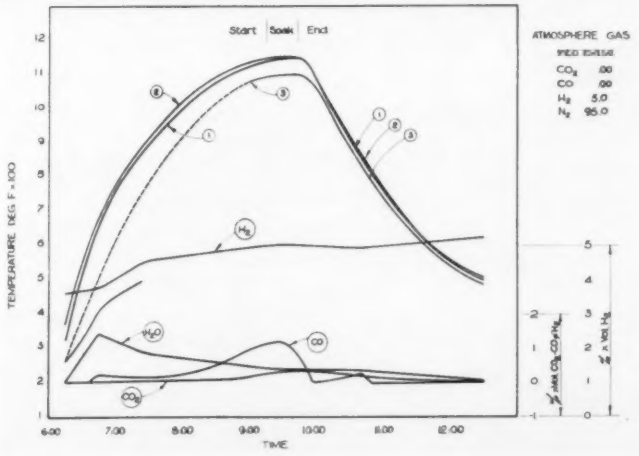
4. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere volumetrically containing from 5 per cent water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time long enough to practically eliminate the yield point.

5. A method of treating strain-aging steel, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce said aging and for a time rendering said steel practically free from said aging.

6. A method of treating strain-aging steel, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce said aging and for a time rendering said steel practically free from said aging, said atmosphere containing water vapor in an amount less than causes material scaling but sufficient to materially reduce said time as compared to its length when said atmosphere does not contain said water vapor.

7. A method of treating strain-aging steel, compris-

Figure 10 — Test cycle for annealing tinplate uses a hydrogen-nitrogen gas with about five per cent hydrogen.



ing holding said steel in an atmosphere volumetrically containing from 5 per cent water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce said aging, and for a time long enough to materially reduce said aging.

8. A method of treating strain-aging steel, comprising holding said steel in an atmosphere volumetrically containing from 5 per cent water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce said aging, and for a time long enough to practically eliminate said aging.

Literature research also uncovered an article by W. A. Pennington, "A Mechanism of the Surface Decarburization of Steel," published in the Transactions of the American Society for Metals 1946, Volume 37. The following excerpts from this paper are most vital to the phenomena of gas alloying[2]:

"A study has been made of the decarburization of an ordinary carbon steel of eutectoid composition at temperatures from 1275 to 1700 F (690 to 925 C) at intervals of temperature which were in general 50 F. A mixture of hydrogen and water vapor containing approximately 20 per cent (by volume) of water vapor was used as a medium to effect the decarburization. Water vapor has been regarded as a reactant and not as a catalyst. Dew point of this gas is +140 F.

"Carbon has been regarded as reaching the surface by diffusing in solid solution as either dissolved elementary carbon or iron carbide, regardless of whether the iron is in the austenitic or ferritic condition. Moreover, the diffusion has been looked upon as being actuated by the pulling action of the chemical reaction which takes place at the surface of the steel resulting in carbon removal.

"Any substance which can oxidize iron carbide may be used to effect decarburization. Oxygen, water vapor and carbon dioxide are particularly effective, especially if they are present in relatively small amounts in gases like hydrogen and nitrogen. The substance which oxidizes the iron carbide is much more effective if at the same time it is not able to oxidize the iron, thereby producing an interfering scale. Accordingly, steam, which will oxidize both, is not as effective as a mixture of water vapor and hydrogen.

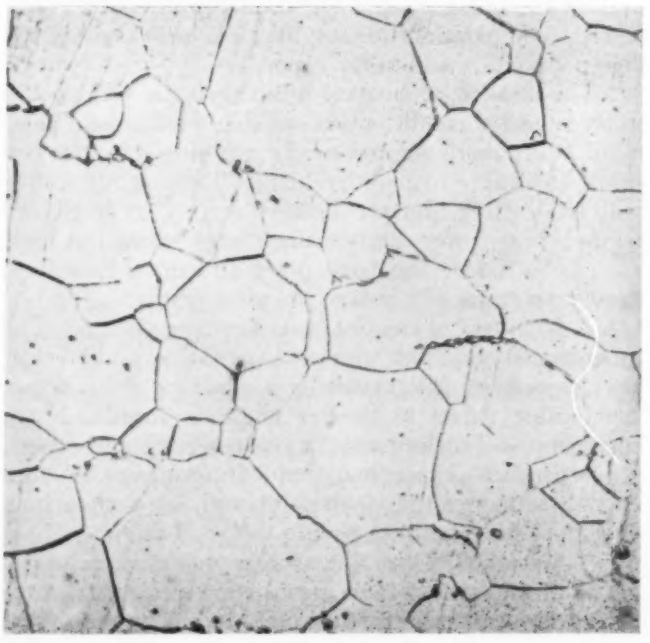
"Hatfield, Emmons, Stead and Wagner[3] have recognized the powerful influence of carbon dioxide in removing carbon from steel. It is not necessary, however, to assume with Stead that oxygen, water vapor, and the like may only be the means of producing carbon dioxide which is really responsible for the action. It is true that if carbon dioxide is produced, and in many cases it is, it will function as depicted, but there are many cases of decarburizing with gases where carbon dioxide is either not formed in appreciable quantities, or it is swept out of the reaction chamber with the flowing gases.

"A mixture of gas, whose carbon dioxide-carbon monoxide ratio is 0.58 and the sum of whose partial pressures is one atmosphere, is an excellent decarburizing agent at temperatures from 1400 F (760 C) upwards. At 1400 F this mixture is neither reducing to ferrous oxide nor oxidizing to elementary iron. If the carbon dioxide concentration is increased very much, the decarburizing rates decrease due to the scaling. If, on the other hand, the concentration is decreased, the rates are also decreased in response to the law of mass action, and of course, if the decrease in concentration is carried far enough, the mixture becomes carburizing.

"To speak of carbon dioxide as being a weak decarburizer is very misleading. It is true that only a slight effect, as has been pointed out, is produced if the

Figure 11 — Cold rolled, hard rimmed enamel steel shown has the following percentage analysis: carbon 0.055, sulphur 0.025, phosphorus 0.010, nitrogen 0.0032. Magnification is 500×. Dark areas indicate presence of carbon.

Figure 12 — Annealed rimmed decarb enamel steel shown has the following percentage analysis: silicon 0.01, manganese 0.35, sulphur 0.023, phosphorus 0.007, aluminum 0.001, nitrogen 0.0033, conductometric carbon 0.002. Magnification is 500×. Note large grains and lack of carbon.



purge gas is used. This condition does not, however, result from any weak decarburizing power of carbon dioxide, but rather is due to the inhibition of the scale produced. The mixture of gas with a carbon dioxide-carbon monoxide ratio of 0.58 at 1400 F (760 C) is not as effective as some mixtures of hydrogen and water vapor, but still a very good decarburizing medium."

From this data it will be noted that the possibilities of gas alloying have been known for many years. It was not until open coiling that this process could be used economically. This major break-through in technique may well save industry millions of dollars.

CHEMISTRY OF DECARBURIZING

A study of the Gensamer process and the Pennington papers shows the three gases that cause the decarburization of steel are: H_2O (water vapor); CO_2 (carbon dioxide); and H_2 (hydrogen).

Assuming carbon diffuses in the solid state to the surface of steel, the following reactions take place to complete the decarburizing reaction[4].

1. H_2O reaction:
$$Fe_3C \text{ (in sol)} + H_2O = 3Fe + CO + H_2$$
$$C \text{ (in sol)} + H_2O = CO + H_2$$
2. CO_2 reaction:
$$Fe_3C \text{ (in sol)} + CO_2 = 3Fe + 2\,CO$$
$$C \text{ (in sol)} + CO_2 = 2CO$$
3. H_2 reaction:
$$Fe_3C \text{ (in sol)} + 2H_2 = 3Fe + CH_4$$
$$C \text{ (in sol)} + 2H_2 = CH_4$$

The No. 3 reaction (H_2) is a slow reaction and is accelerated by H_2O vapor. In reaction No. 1 the H_2O vapor is regarded as a reactivant not as a catalyst. The presence of H_2 and/or CO (carbon monoxide) serves to keep the surface of the steel clean.

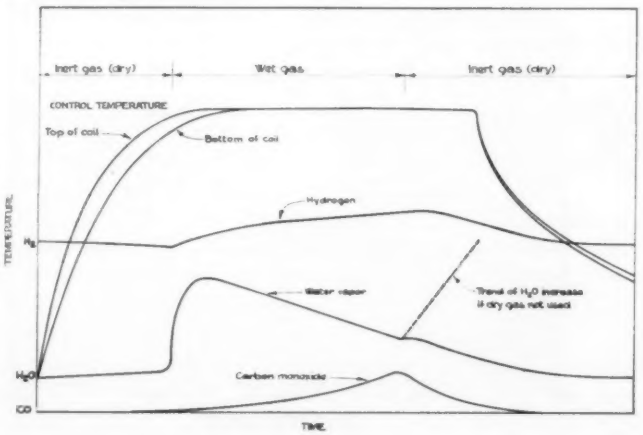
A rather nontechnical theory of the removal of carbon and nitrogen from steels follows.

The steel is heated to approximately 1200 F in an atmosphere (a) inert or (b) reducing.

The atmosphere gas is gradually changed to a highly decarburizing gas or gases.

At annealing temperature the grain structure starts a gradual movement to enlargement of the grains. Small elongated grains combine to make up single large

Figure 13 — This hydrogen-nitrogen gas annealing cycle shows the gas reactions.



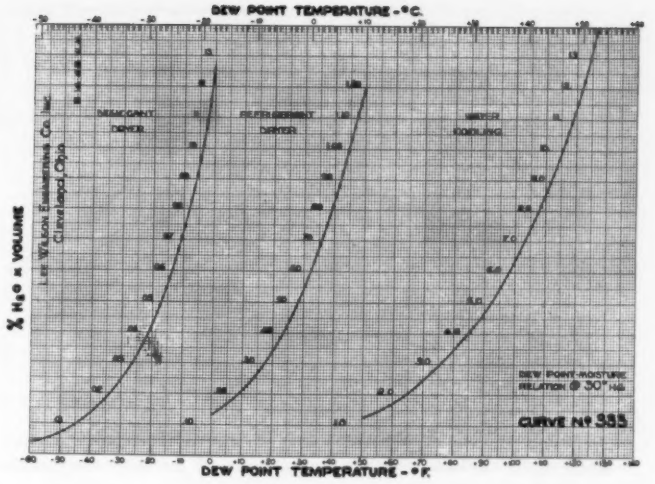


Figure 14 — Chart gives relative moisture content of gases in per cent by volume at various dew point temperatures.

grains. This build-up increases the pressure within the grain boundaries, forcing the interstitial constituents to attempt to escape. The carbon diffuses as C or Fe_3C. If the atmosphere at the surface of the steel is decarburizing, the carbon will be carried away by any one of the following reactions:

$$C + H_2O = CO + H_2$$
$$Fe_3C + H_2O = 3Fe + CO + H_2$$
$$C + CO_2 = 2CO$$
$$Fe_3C + CO_2 = 2CO + 3Fe$$

As long as the temperature continues to enlarge grains and the surface atmosphere continues to carry away the diffused carbon, carbon will be removed from the steel.

This internal pressure also forces the insoluble or free nitrogen to the surface of the steel along with the carbon.

Any surface obstruction such as a change in gas equilibrium causing oxidation, carburizing or equilibrium conditions between the carbon in the gas and the carbon in the steel, will slow down or stop the decarburizing reaction.

GRAIN SIZE

The terminology "grain size" is quite a common expression with metallurgists but may be somewhat confusing to the average person. Figure 11 shows cold rolled strip unannealed. Figure 12 shows annealed strip with carbon removal having taken place.

CYCLE OF REACTIONS IN GAS ALLOYING

Figure 13, plotted on a time-temperature graph, using hydrogen nitrogen gas as an atmosphere, follows the gas reactions through the alloying cycle.

The cycle starts by purging the furnace with an inert dry atmosphere. As the steel is heated, the temperature curve gradually climbs to control temperature. The hydrogen content of the exhaust gas remains constant through this period. The H_2O content in the exhaust gas rises very gradually. At a point close to control temperature the moisture content of the

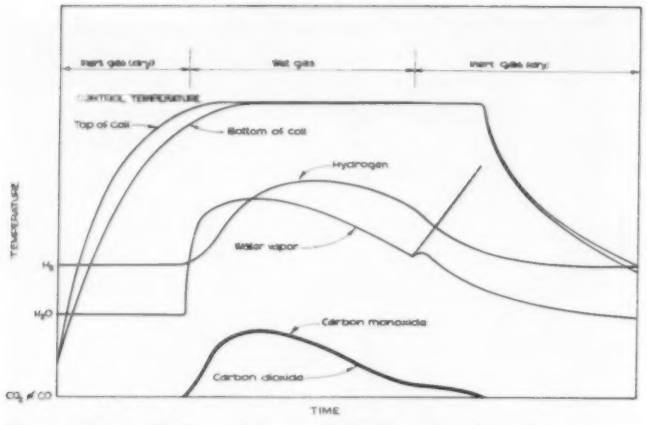


Figure 15 — This cycle uses a hydrogen-nitrogen gas enriched with carbon dioxide and water. A carbon monoxide to carbon dioxide ratio of 1.0 is indicated.

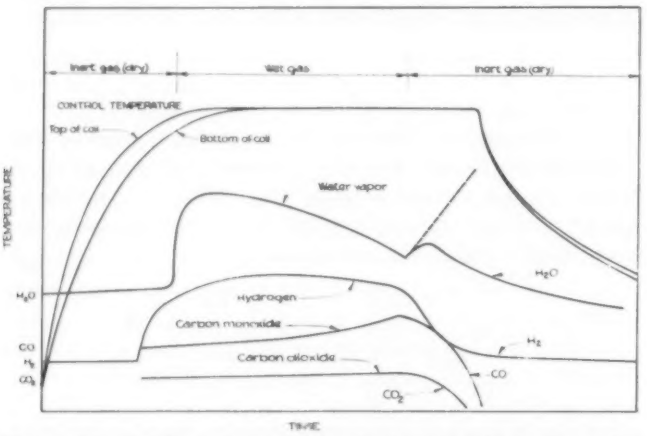


Figure 16 — This cycle uses a dry hydrogen-nitrogen gas for purge and a wet hydrogen-nitrogen-carbon dioxide-carbon monoxide gas for soak. A carbon monoxide to carbon dioxide ratio of 1.5 is indicated.

entering gas is increased to the desired dew point. At this time a very marked increase in the exhaust dew point will show up. Gradually CO is formed in the exhaust gases. A gradual increase in the H_2 content of the exhaust gas is also seen. Remember at this point there is a constant flow of H_2 and no CO in the entering gas. Also at this time there is a marked drop off in exhaust dew point, even though there is a relatively high dew point in the entering gas.

The gradual rise of both H_2 and CO continues through the soak portion of the alloying cycle to a point where there is a sudden increase in exhaust dew point and a marked decrease in H_2 and CO. At this point the wet gas additions are stopped and a dry inert gas continues to flow through the furnace. This purge (at temperature) is continued until a satisfactory exhaust dew point is reached. The cooling cycle of the steel is then started.

It is also noticed at this time that the H_2 content of the exhaust gas decreases to a point where it matches the incoming gas. The CO content of the exhaust gas decreases fairly rapidly to 0.0 per cent.

Figure 14 shows the relative moisture content of gases (per cent × volume) at various dew point temperatures.

When using atmosphere gases containing H_2, H_2O and N_2 the diffused carbon has two reactions to effect decarburization:

$$C + H_2O = CO + H_2$$
$$Fe_3C + H_2O = 3Fe + CO + H_2$$

However, if we add CO_2 to these gases a total of four reactions are possible, namely,

$$C + H_2O = CO + H_2$$
$$Fe_3C + H_2O = 3Fe + CO + H_2$$
$$C + CO_2 = 2CO$$
$$Fe_3C + CO_2 = 2CO + 3Fe$$

This would indicate that a gas containing H_2O, H_2 and CO_2 may be as effective, or more effective, in removing carbon than a gas containing only H_2, H_2O and N_2. The use of gases containing only N_2, H_2 and H_2O warrants the use of very high entering dew points. When using gases containing CO_2, the entering dew points are somewhat lower.

The lower dew point gases are much simpler to read and control. The high dew point gases are very difficult to read and much less responsive to control. Ambient temperatures affect the high dew point very perceptibly.

EQUILIBRIUM CONSTANTS

As the removal of carbon from steels produces CO in the atmosphere, by adding H_2O and CO_2 with the H_2 and N_2 the equilibrium constant =

$$K_3 = \frac{PH_2 \times PCO_2}{PH_2O \times PCO}$$

becomes the effective constants. As constant K_3 is always lower then $K_1 = PH_2/PH_2O$ in any given temperature range, lower dew points and better control of these dew points could be realized. P indicates partial pressure percentage.

Figure 15 indicates a cycle utilizing this type of atmosphere. This cycle could be set for a CO/CO_2 ratio of 1.0 or 1.5. Ratio 1.0 indicated.

This cycle indicates that a rather rigid control of the entering CO_2 gas would be required. For this reason a cycle as shown on Figure 16 would be a more satis-

Figure 17 — Chart shows equilibrium relations for steel at various temperatures.

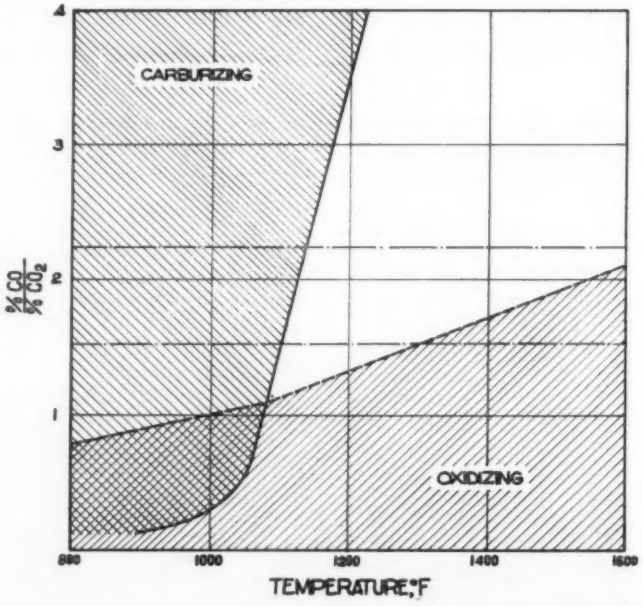


TABLE I
Equilibrium Constants for Reactions 1 to 5°

t, C	t, F	$K_1 = \frac{PH_2}{PH_2O}$	$K_2 = \frac{PCO}{PCO_2}$	$K_3 = \frac{PH_2 \times PCO_2}{PH_2O \times PCO}$	$K_4 = \frac{P^2CO}{PCO_2}$	$K_5 = \frac{P^2H_2}{PCH_4}$
400	752	9.12*	0.74*	12.3	9×10^{-5}	5.66×10^{-2}
450	842	6.38*	0.86*	7.38	7.3×10^{-4}	0.164
500	932	4.68*	0.96*	4.88	4.7×10^{-3}	0.422
550	1022	3.53*	1.03*	3.45	0.023	0.977
600	1112	2.99	1.17	2.55	0.096	2.09
650	1202	2.65	1.35	1.96	0.343	3.92
700	1292	2.38	1.53	1.56	1.06	7.16
750	1382	2.17	1.72	1.27	2.96	12.3
800	1472	2.00	1.90	1.05	7.48	20.1
850	1562	1.84	2.07	0.891	17.46	31.8
900	1652	1.72	2.24	0.765	37.76	48.3
950	1742	1.61	2.41	0.668	76.70	71.0
1000	1832	1.51	2.57	0.589	146.5	102.4
1050	1922	1.44	2.72	0.527	264.0	141.2
1100	2012	1.37	2.88	0.474	463.4	192.0
1150	2102	1.31	3.03	0.433	767.4	256.0
1200	2192	1.26	3.21	0.395	1244	335.0
1250	2282	1.22	3.36	0.363	1945	431.5
1300	2372	1.18	3.49	0.339	2951	547.0

* Stable oxide at this temperature is Fe_3O_4 not FeO; the equilibrium constants so marked are not so accurate as the others.

factory cycle. This cycle utilizes a dry purge with inert gas, the use of a humidified exothermic generated gas, at a 6 to 1 air-to-gas ratio, for soak. Repurge with dry inert gas for dry soak and cooling.

This graph indicates a gradual increase of CO over CO_2 and a gradual increase of H_2 over H_2O.[5]

Figure 17 shows the advantage of the CO over CO_2 increase in that the gas equilibrium stays in the decarburizing area safely above the oxidizing line.

The atmosphere gases used for heat treating purposes generally fall into five categories—oxidizing, reducing, carburizing, decarburizing and neutral. These reactions, in turn, fall into three groups.

1. Oxidizing $\rightleftarrows$ reducing.
2. Carburizing $\rightleftarrows$ decarburizing.
3. Neutral.

The arrows in groups 1 and 2 indicate they are reversible reactions. The direction of the reaction is determined by the gas composition and temperature. As atmosphere gases at all times will attempt to reach an equilibrium condition at a given temperature, any one of four reactions, in the first two groups, can be accomplished by control of the atmosphere gas composition.

In Table I[6], the equilibrium constants for various gases are shown. From this table Figure 18 is plotted for constants K_1, K_2 and K_3. The right-hand side of this curve is in the decarburizing reaction range.

A study of these equilibrium constants will help determine the correct gas analysis required for the decarburizing cycles.

The time-temperature graphs seen so far are satisfactory cycles for the removal of C and N_2 for all cycles except the cycle for nonaging steel.

This cycle calls for the use of pure hydrogen atmosphere with the addition of water vapor, final analysis being 80 per cent H_2, and 20 per cent H_2O. Figure 19 shows a theoretical cycle for steel treatment for nonaging.

Figure 20[7] shows the influence of strip thickness on time of H_2 treatment with fixed gas and temperature.

Table II[8], shows the time required for elimination of yield point and strain-aging using various mixtures of hydrogen and water vapor.

Figure 21 shows the removal of carbon from strip is not a straight-line function, but is a gradually diminishing curve flattening quite perceptibly at a

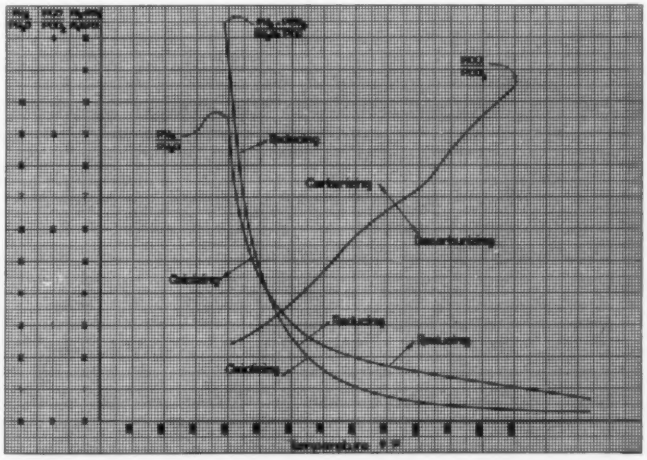
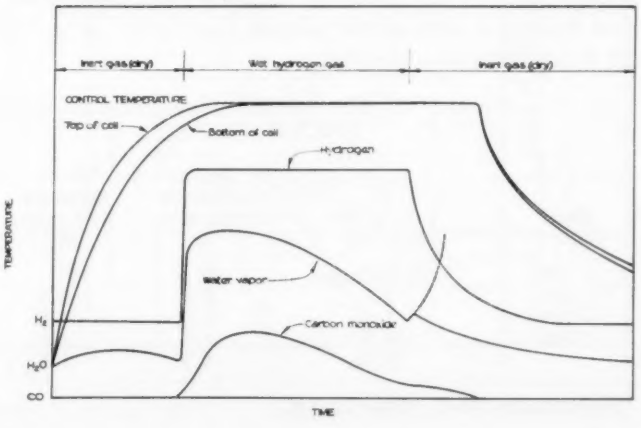


Figure 18 — Curves give equilibrium constants for various gas mixtures.

Figure 19 — Cycle uses a dry hydrogen-nitrogen gas with a −40 F dew point for purge and a wet hydrogen gas with a +140 F dew point for soak.



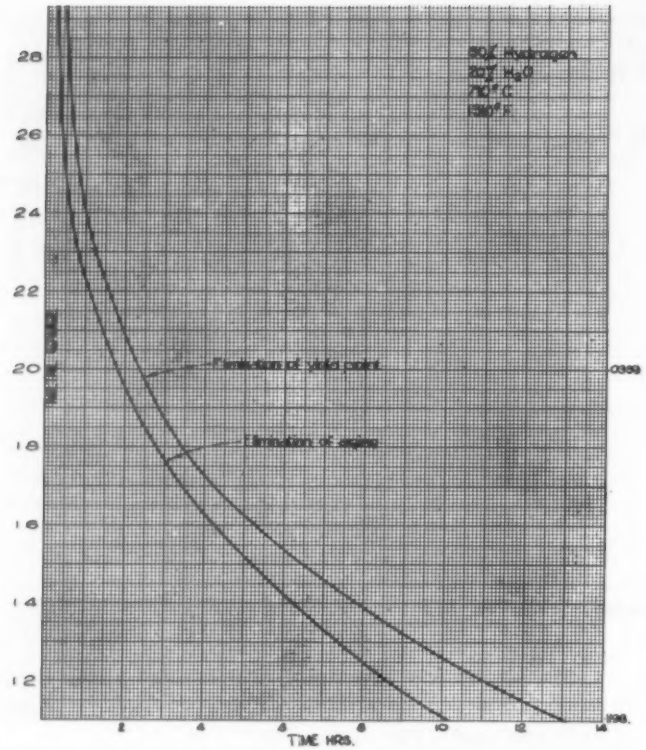


Figure 20 — Strip thickness is an important factor on the time for treatment with hydrogen.

point of 0.005 per cent carbon. This curve is theoretical but can be assumed to be quite close to actual.

DIFFUSION OF GASES

It has been mentioned that the removal of carbon and nitrogen is due to the diffusion of the interstitials in the solid or gaseous form. This intermixing of gases can be explained by the kinetic theory of gases and the rate of diffusion of gases.

When more than two gases are involved, equations for expressing the rate of diffusion become complicated and unwieldy. However, the phenomena of diffusion can be basically explained by just considering two gases.

The speed at which gaseous molecules travel is a function of the size of the molecule and the temperature. The smaller the molecule, the faster it will travel. Hence, hydrogen, which is the lightest gas known, will travel faster than any of the known gases.

The basic rate of diffusion is explained on the kinetic theory by Graham's law. This law states that the rates of diffusion of gases are inversely proportional to the square roots of the densities of the gases. This means that hydrogen will diffuse almost four times as fast as air under the same conditions.

TABLE II

Dew point, F	Volume per cent H_2O	Time to eliminate strain-aging, hr	Time to eliminate yield point, hr.
− 60	Tank hydrogen	20	140
+ 87	4.7	2.5	3.0
+105	7.5	2.0	2.5
+140	20.0	1.5	2.0
	29.1	1.5	1.5

Temperature 710 C. Gage 0.033 in.

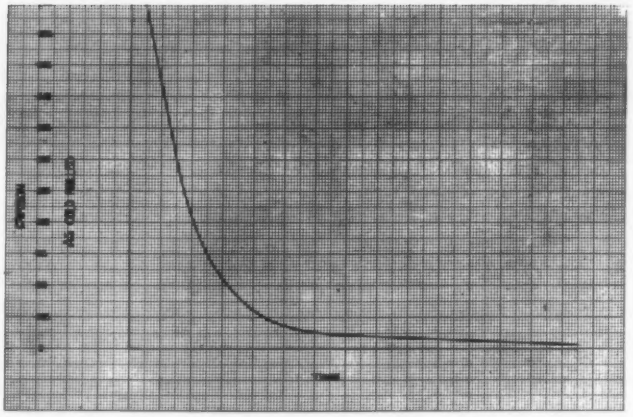


Figure 21 — Rate of carbon removal is a function of the carbon present.

It must be understood that all gases try to maintain or reach an equilibrium condition as far as pressure and composition are concerned. If two gases are maintained on either side of an impermeable partition in a closed cylinder, and the partition is suddenly removed, the gases immediately begin to diffuse because of the large amount of space between molecules. After some time, the gases will have reached equilibrium and the concentration of percentage composition will be the same throughout the cylinder. This intermixing is due only to the diffusion of one gas in another.

As explained above, when more than two gases are involved, the rate of diffusion is not so easily explained. Partial pressures and temperatures then enter into the picture. Partial pressures can be explained as follows.

The pressure exerted by a gaseous mixture on the walls of a container is due to the combined collisions of all the molecules on the wall regardless of their types. It is sometimes desirable to evaluate that part of the total pressure which is due to a particular type of substance. Each constituent will produce a partial pressure, or contribution to the total pressure, which is dependent on its relative abundance, or concentration, in the mixture.

These facts are contained in Dalton's law, which holds only for an ideal gas. It may be stated as follows: each gas of a mixture exerts a partial pressure equal to the pressure which the same mass of the gas would exert if it were present alone in the given space at the same temperature. Essentially, the law implies independence of action of the molecules of a mixture.

Two mathematical expressions are used in connection with Dalton's law. They are:

$$P_r = P_a + P_b + P_c, \text{ etc.}$$
$$P_i = P_t X_i$$

The first states that the total pressure is the sum of the partial pressures of the various kinds of molecules which are present in the mixture, while the second states that the partial pressure of any species in a mixture can be evaluated as the product of the total pressure and the mole fraction of that species in the mixture. It is to be noted that mole fraction and volume fraction are equivalent for ordinary gaseous mixtures.

To illustrate an application of the principle, suppose that a gas consists of 80 per cent methane, 10 per cent ethane, 5 per cent nitrogen and 5 per cent carbon dioxide. If the total pressure in the system is 20 psig, what are the partial pressures of the components,

according to Dalton's law?

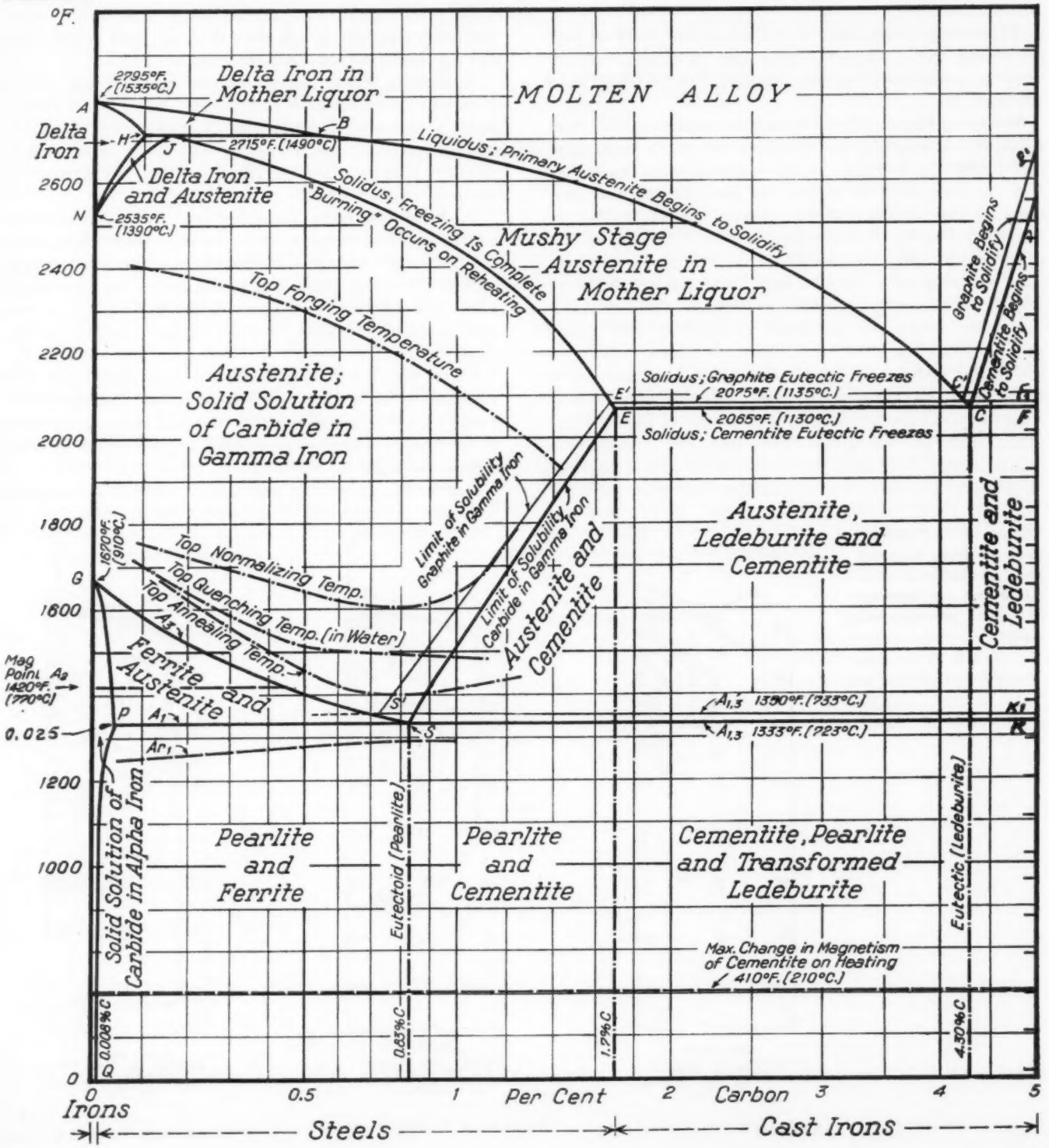
Total pressure, psi	= 20	+ 14.7	= 34.7
Partial pressure of methane, psi	= 34.7 ×	0.80	= 27.76
Partial pressure of ethane, psi	= 34.7 ×	0.10	= 3.47
Partial pressure of nitrogen, psi	= 34.7 ×	0.05	= 1.74
Partial pressure of carbon dioxide, psi	= 34.7 ×	0.05	= 1.74
	Total pressure		= 34.71

EFFECT OF TEMPERATURE ON GAS ALLOYING

Temperature function in gas alloying has been explained with its relationship to the gas reactions. Temperature is also directly connected to the metallurgical results obtainable during annealing. In listing a typical analysis of open hearth sheet steels they have the following percentage compositions.

Rimmed steel
0.08 C; max = 0.10, min. = 0.04
0.33–0.45 Mn
0.010 P
0.025 S

Figure 22 — The iron-iron carbide equilibrium diagram forms a fundamental guide in establishing temperatures for heat treatment.



0.08 Cu
0.04 Ni
0.015 Si
0.nil Al
0.003–0.006 N
Killed steel
0.05 C, max
0.25–0.30 Mn
0.010 P
0.030 S
0.08 Cu
0.04 Ni
0.015 Si
0.020–0.060 Al
0.003–0.006 N

This composition indicates that at the start of any annealing cycle rimmed steels can, and do, contain varying amounts of carbon ranging from 0.04 to 0.10 per cent.

Studying Figure 22, the iron, iron carbide equilibrium diagram, on heating, the composition exists as pearlite and ferrite (beta iron). As the temperature approaches the A_1 line, H_2O is added to the atmosphere gas, starting the carbon removal process. As the carbon is removed, the steel composition moves to the left of the diagram changing to a solid solution of carbide in alpha iron. Quoting an excerpt from the Gensamer & Lowe paper; "Annealing low-carbon sheets in wet hydrogen has been found to eliminate completely the yield-point elongation that is typical of these steels, to lower the yield point stress to values less than have been reported previously even for the purest iron (fine grained) and to eliminate all traces of both strain-aging and quench-aging. The principal changes in composition that have been observed are a marked lowering of the carbon and nitrogen contents while the oxygen content (as determined by vacuum-fusion methods) is unaffected or slightly increased. The only observable change in microstructure accompanying the changes is a disappearance of visible carbides and a decrease in the sharpness of the ferrite grain boundaries as developed by etching. The times required to eliminate strain-aging and to eliminate the yield point are probably the same."

It would appear from this concept that temperatures above 1350 F would not be required to obtain desirable carbon reduction. The higher temperatures may also be detrimental to increasing the metal grain size.

What does this mean to steel producers? To answer this one must first define rimmed and killed steels:

Rimmed steel—An incompletely deoxidized steel normally containing less than 0.25 per cent carbon and having the following characteristics:

1. During solidification, an evolution of gas occurs sufficient to maintain a liquid ingot top ("open steel") until a side and bottom rim of substantial thickness has formed. If the rimming action is intentionally stopped shortly after the mold is filled, the product is termed "capped steel."

2. After complete solidification, the ingot consists of two distinct zones; a rim somewhat purer than when poured, and a core containing scattered blowholes with a minimum amount of pipe and having an average metalloid content somewhat higher than when poured and markedly higher in the upper portion of the ingot.

From the description there is a good likelihood that rimmed steel will be inconsistent in its structure. From this one could assume that the structure within strip steel is variable according to its initial location within the ingot.

Figure 23 shows the segregation of carbon, sulphur

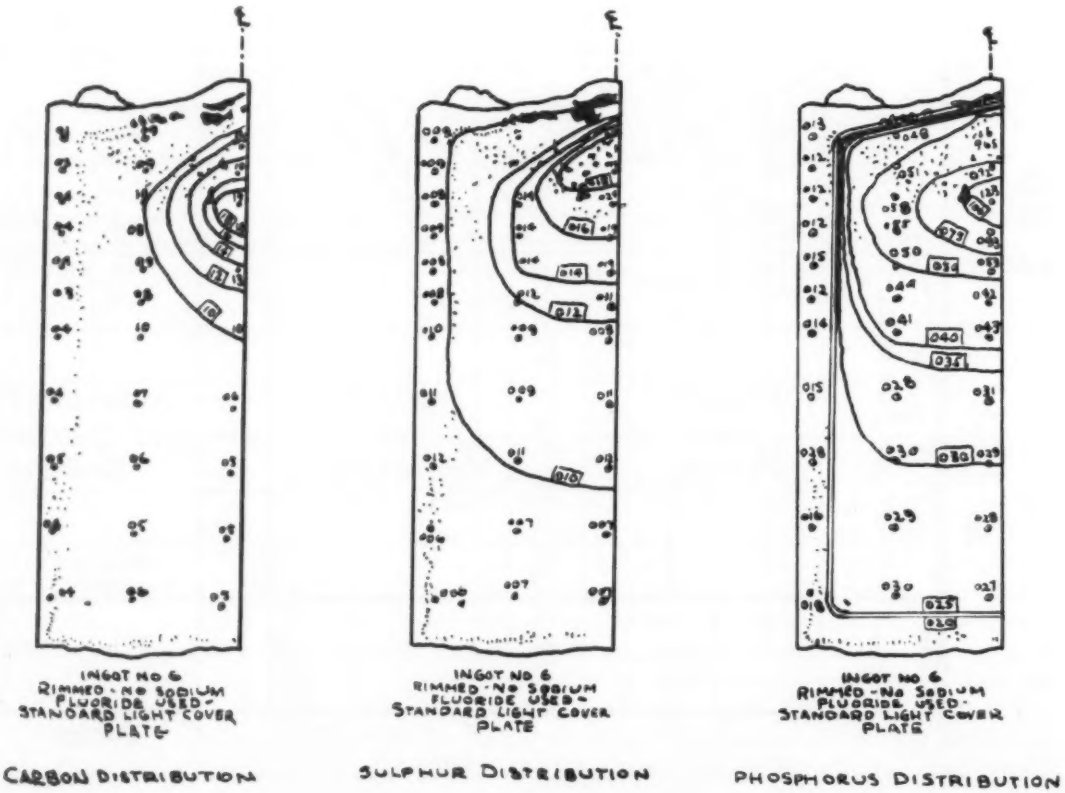

INGOT NO 6
RIMMED - NO SODIUM FLUORIDE USED - STANDARD LIGHT COVER PLATE
CARBON DISTRIBUTION
INGOT NO 6
RIMMED - NO SODIUM FLUORIDE USED - STANDARD LIGHT COVER PLATE
SULPHUR DISTRIBUTION
INGOT NO 6
RIMMED - NO SODIUM FLUORIDE USED - STANDARD LIGHT COVER PLATE
PHOSPHORUS DISTRIBUTION

Figure 23 — Sections show carbon, sulphur and phosphorus distribution in section of ingot of rimmed steel.

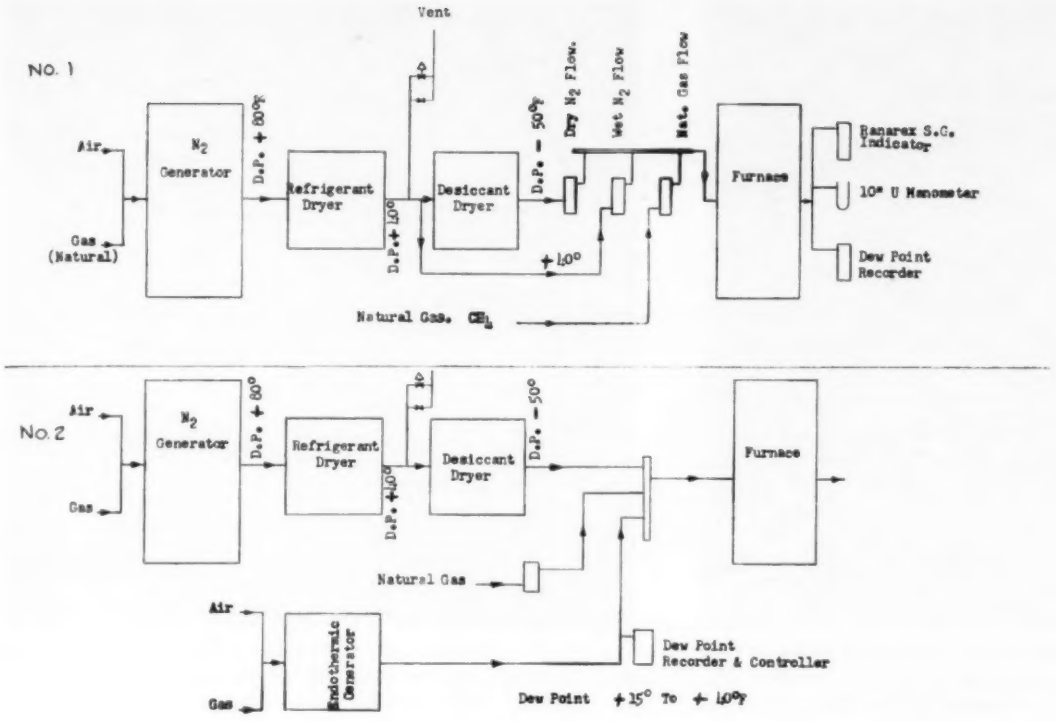


Figure 24 — Schematic layout of two carbon restoration systems.

and phosphorous in a half section of a poured ingot. To overcome this segregation necessitates the use of killed steel. This is a steel sufficiently deoxidized to prevent gas evolution during solidification. The top surface of the ingot freezes immediately and subsequent shrinkage produces a central pipe. A semi-killed steel, having been less completely deoxidized, develops sufficient gas evolution internally in freezing to replace the pipe by a substantially equivalent volume of rather deep-seated blowholes.

The effects produced by the addition of aluminum to steel are as follows:

1. Degasifies and deoxidizes molten steel during the refining, tapping and teeming stages, thus contributing to the production of sound steel.

2. Retards grain growth; elevates the coarsening temperature. Aluminum is effectively used in controlling austenitic grain size in carbon and alloy steels.

3. Increases the density, strength and hardness by virtue of solid solution in the iron matrix.

4. About 1.00 to 1.25 per cent aluminum in nitriding steels aids in producing a uniformly hard and strong nitrided surface layer when nitrided with ammonia at a relatively low temperature of 950 to 1020 F.

Normally steel producers used rimmed steel for drawing purposes because of its superior surface finish. However, for extra deep drawing quality, the more expensive killed steel is necessary because of the carbon segregation. Gas alloying may be utilized to eliminate this carbon segregation.

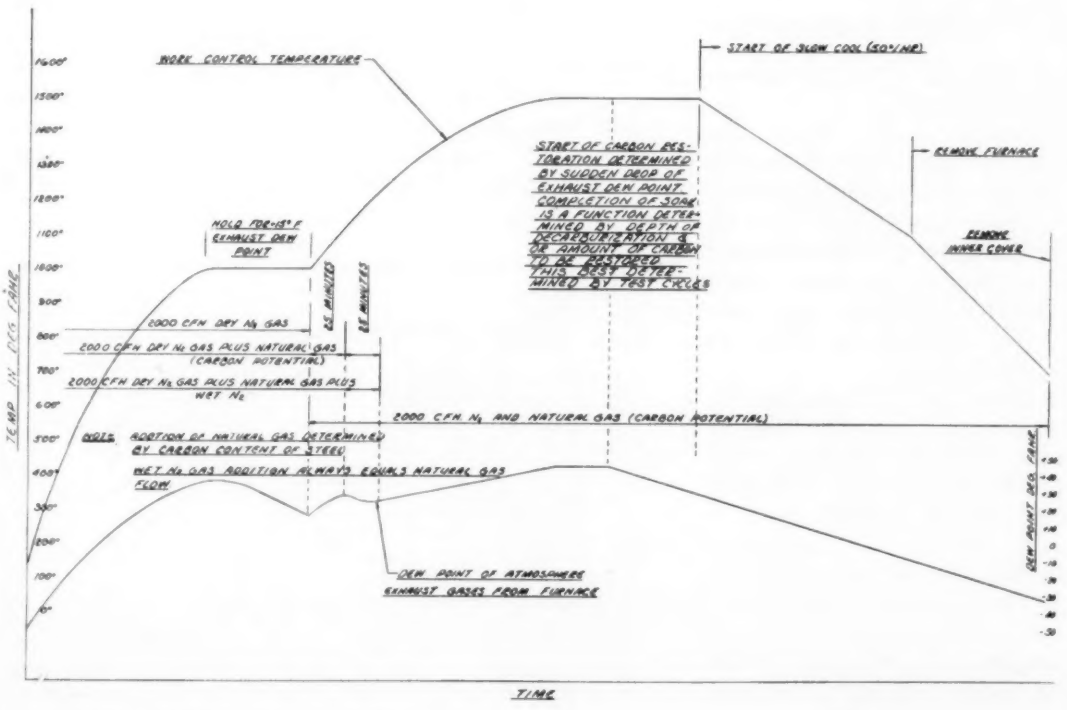

WORK CONTROL TEMPERATURES
START OF SLOW COOL (50°/HR)
START OF CARBON RESTORATION DETERMINED BY SUDDEN DROP OF EXHAUST DEW POINT
COMPLETION OF SOAK IS A FUNCTION DETERMINED BY DEPTH OF DECARBURIZATION OR AMOUNT OF CARBON TO BE RESTORED
THIS MUST BE DETERMINED BY TEST CYCLES
REMOVE FURNACE
REMOVE INNER COVER
HOLD FOR -50°F EXHAUST DEW POINT
2000 CFH DRY N_2 GAS
2000 CFH DRY N_2 GAS PLUS NATURAL GAS (CARBON POTENTIAL)
2000 CFH DRY N_2 GAS PLUS NATURAL GAS PLUS WET N_2
2000 CFH N_2 AND NATURAL GAS (CARBON POTENTIAL)
NOTE: ADDITION OF NATURAL GAS DETERMINED BY CARBON CONTENT OF STEEL
WET N_2 GAS ADDITION ALWAYS EQUALS NATURAL GAS FLOW
DEW POINT OF ATMOSPHERE EXHAUST GASES FROM FURNACE
TEMP IN DEG. F
DEW POINT DEG. F
TIME

Figure 25 — Graph gives carbon restoration cycle using equipment shown in the top half of Figure 24.

Figure 26 — Micrograph shows the structure of hard tinplate with the following percentage analysis: carbon 0.078, silicon 0.01, sulphur 0.023, nitrogen 0.0044. Magnification is 500×.

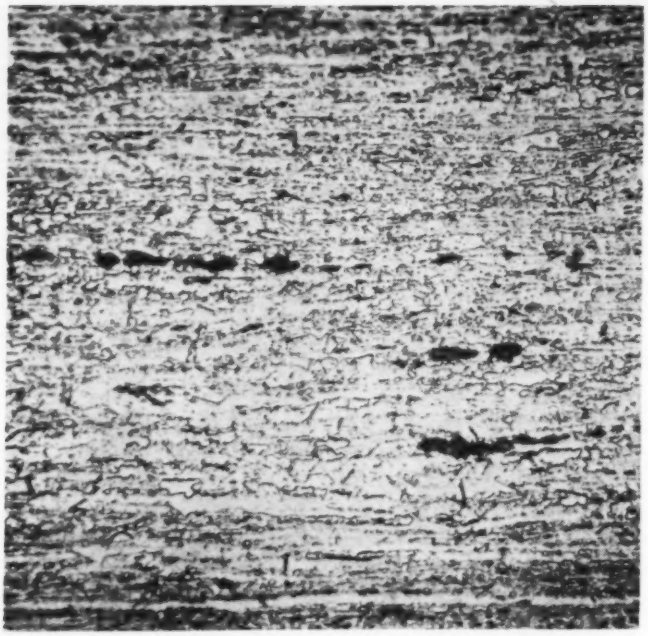


Figure 27 — Micrograph shows the structure of annealed and nitrided tinplate with the following percentage analysis: carbon 0.074, silicon 0.01, manganese 0.46, sulphur 0.031, phosphorus 0.009, aluminum 0.003, nitrogen 0.13.

POSSIBILITIES OF GAS ALLOYING

To this point the gas alloying procedure for the removal of carbon and nitrogen from steel has been discussed. Correct control of this process can produce:

1. Nonaging steel.
2. Enamel iron.
3. Extra deep draw rimmed steel.
4. Low-carbon sheet steel as a substitute for low percentage silicon sheet.
5. Improve electrical characteristics of silicon steels.

The next step in this process is the restoring of carbon and nitrogen to steels. These processes will be discussed separately.

CARBON RESTORATION

There are two trends of thought as to the correct method of restoring carbon to steel.

Figure 24 shows the schematic layout of the two carbon restoration systems. System No. 1 shows the schematic layout of a nitrogen generator, refrigerant gas dryer, a desiccant gas dryer, a mixing station for controlling and mixing dry nitrogen gas, wet nitrogen gas and natural gas, prior to entering the furnace unit. It also shows a specific gravity indicator, a pressure manometer, and a dew point recorder, recording the exhaust gas dew point from the furnace.

System No. 2 shows the layout for a nitrogen generator, refrigerant gas dryer, desiccant gas dryer and an endothermic type generator, with dew point recorder controller. Also shown is metering equipment for additional flows of natural gas to the system prior to entering the furnace.

Figure 25 shows graphically the carbon restoration cycle using System No. 1. The sequence of operation is as follows:

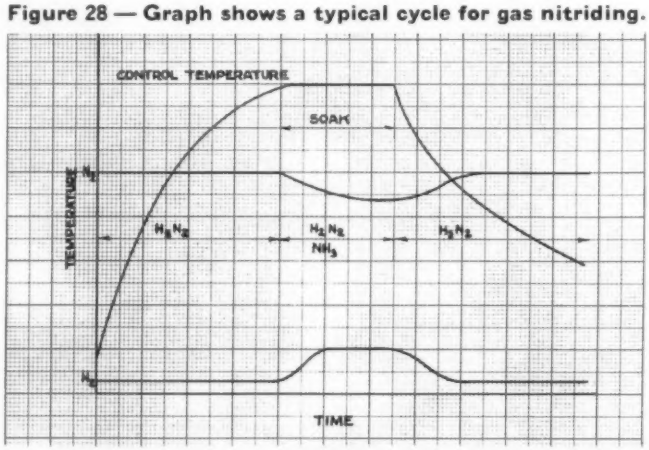
a. With the furnace charged and adequately sealed, the furnace is purged with the correct flow of nitrogen (N_2) gas. This gas is maintained at a dew point of −50 F or lower.

b. At the completion of the purge, the furnace is heated to a steel temperature of 1000 F. The furnace is held at this temperature until an exhaust gas dew point of +15 F is obtained.

c. When the correct dew point is obtained in the exhaust gases the furnace is set at a temperature of 1550 F. At this time an adequate flow of natural gas is added to the initial nitrogen gas to maintain a carbon potential for restoring carbon in the steel to be annealed.

d. When a complete mixture of the nitrogen gas and the natural gas is obtained, a flow of wet nitrogen gas with a dew point of +45 F is also mixed with the first two gases. This gas addition will start a gas reaction within the furnace, indicated by an increase of CO and H_2 in the exhaust gases (by orsat). It will also be indicated by a dropping off of the exhaust gas dew point. At this time the addition of wet nitrogen gas can be stopped. The flow of dry nitrogen and natural gas is maintained throughout the remainder of the annealing cycle.

Figure 28 — Graph shows a typical cycle for gas nitriding.



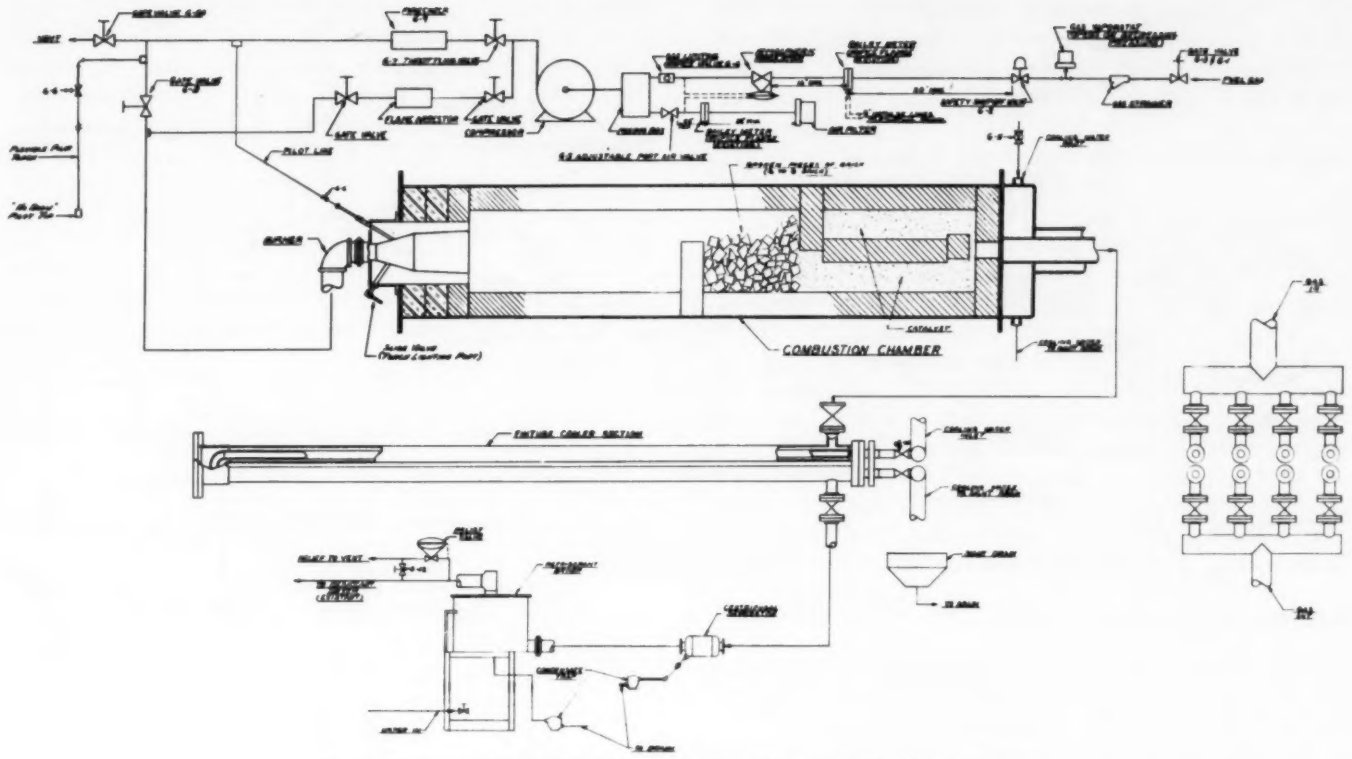


Figure 29 — Equipment used for exothermic, low ratio (deox) cycle.

KEY:
——— ELECTRICAL CONNECTIONS
- - - - - - - - IMPULSE LINES

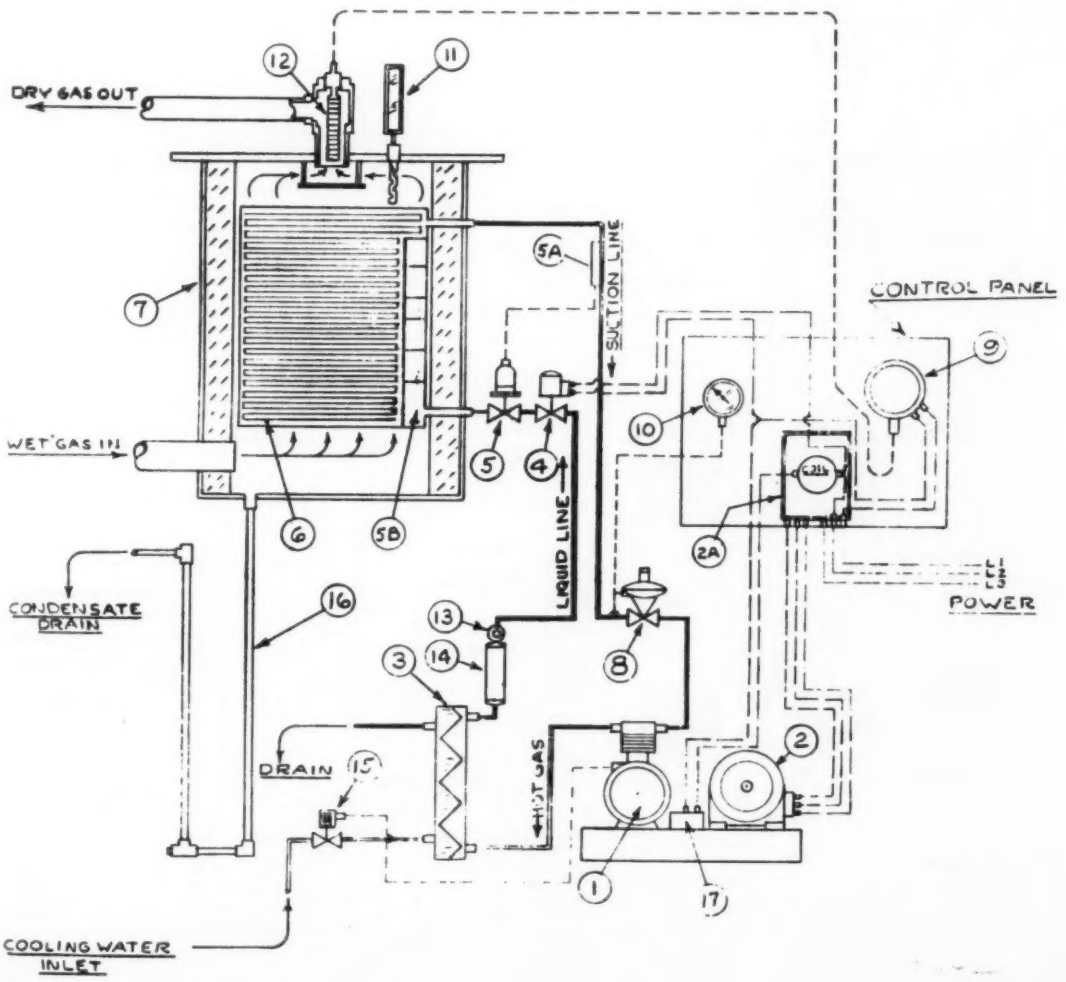


Figure 30 — Schematic layout of refrigerant dryer system.

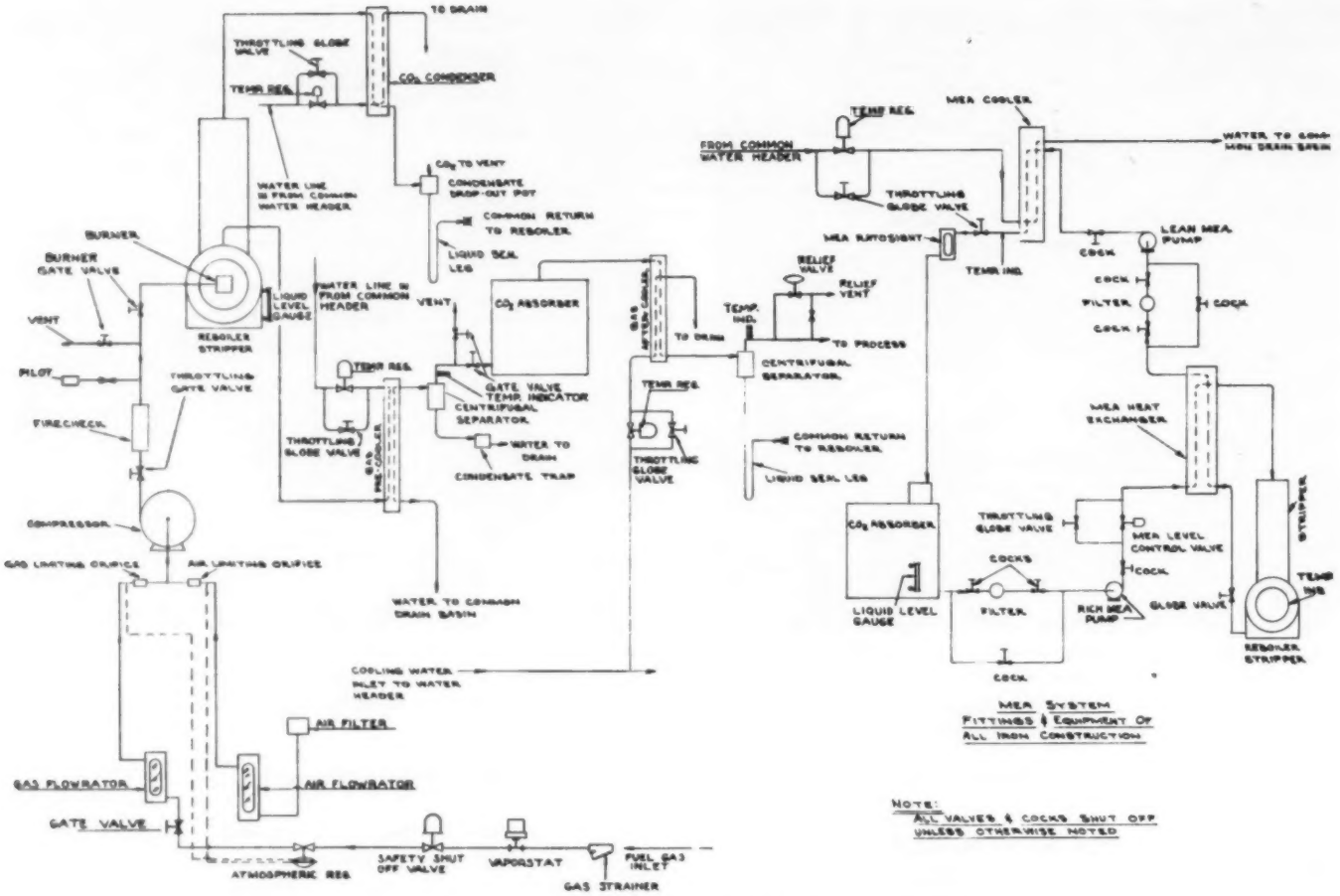


Figure 31 — Schematic of exothermic nitrogen generator.

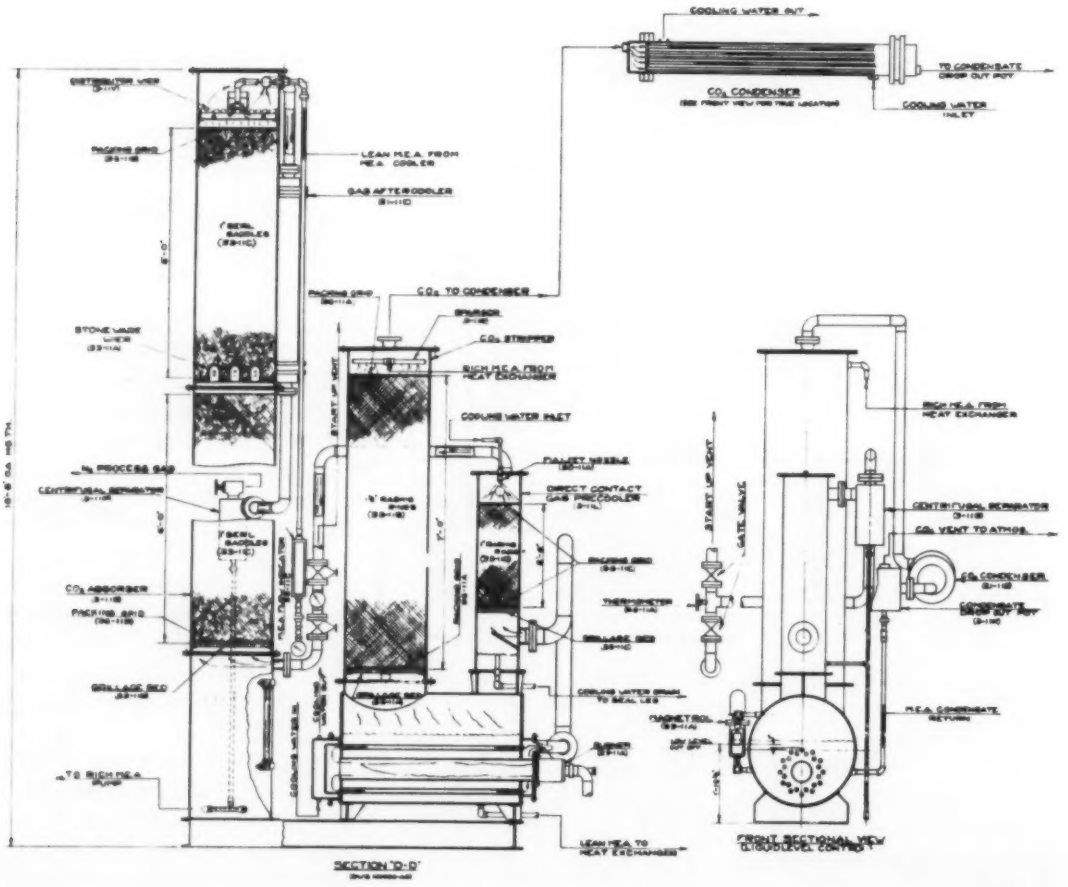


Figure 32 — Cross section of exothermic nitrogen generator.

e. The holding time at temperature should be for a sufficient period to obtain complete penetration of carbon into the steel. The start of carbon restoration is determined by a sudden drop of exhaust dew point. Completion of soak is a function determined by depth of decarburization and/or amount of carbon to be restored. This is best determined by test cycles.

f. The cooling cycle can be controlled to obtain the desired metallurgical structure in the steel being annealed.

With the addition of H_2O by wet N_2 the following reactions take place within the furnace.

$$CH_4 + H_2O = CO + 3H_2$$

This excessive CO reacts with the steel charge.

$$3Fe + 2CO = Fe_3C + CO_2$$

Following this:

$$CO_2 + H_2 = H_2O + CO$$

Once the reactions are started no addition of H_2O is needed as the above reactions are self-supporting.

Carbon molecules of CO reacting with the Fe give the desired carbon potential and restoration.

NITRIDING OF SHEET STEEL

The nitriding process requires heating the material to a temperature of 900 to 1100 F in the presence of anhydrous ammonia. When ammonia dissociates near the surface of the steel, by equation:

$$2NH_3 + \text{heat} = N_2 + 3H_2$$

the very active nascent nitrogen is absorbed by the steel and combined with the alloying elements to form nitrides. Control of temperature, time at temperature and ammonia vapor flows allows control of the depth of nitrides.

Figures 26 and 27 show steel structures and analysis before and after nitriding.

The soak portion of this test cycle was purposefully prolonged to show that unlimited nitriding can be obtained. With proper control of the gas flows, time at temperature and the amount of atmosphere gas used, desired depth of nitriding can be produced.

Figure 28 shows a typical cycle for gas nitriding. In this cycle, during the purge and heating period, hydrogen-nitrogen gas is used. During soak a mixture of hydrogen-nitrogen gas with ammonia vapor is used. The ammonia vapor is admitted to the atmosphere gas line as it enters the base. At the completion of soak, the ammonia vapor is discontinued and the base allowed to repurge with hydrogen-nitrogen gas.

GASES FOR STEEL ALLOYING

The following types of atmosphere gases can be utilized in the gas alloying system.

Exothermic, low ratio (deox)—This protective gas is produced by burning hydrocarbon gases with air at approximately 60 per cent aeration, in a brick-lined chamber, in the presence of a catalyst. The catalyst used is activated alumina impregnated with nickel. The combustion chamber temperature is normally between 2200 and 2300 F. The temperature drop across the catalyst should be approximately 300 F. This should bring the catalyst chamber to a tempera-

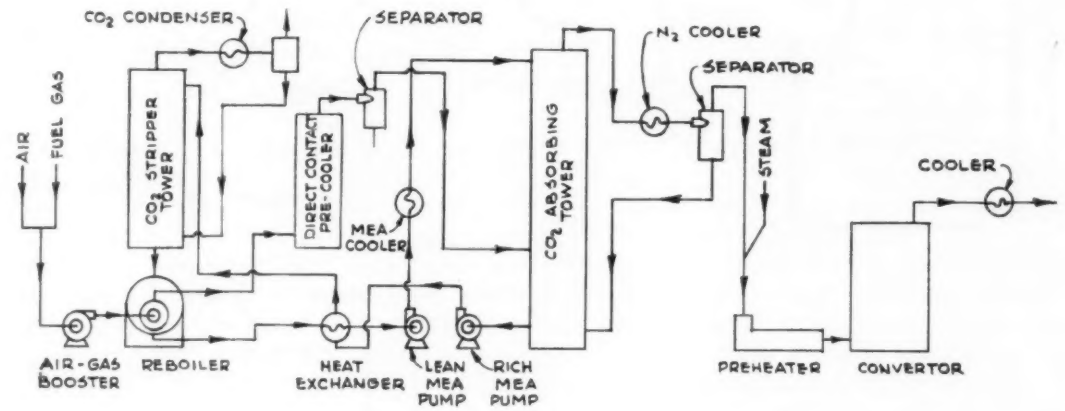
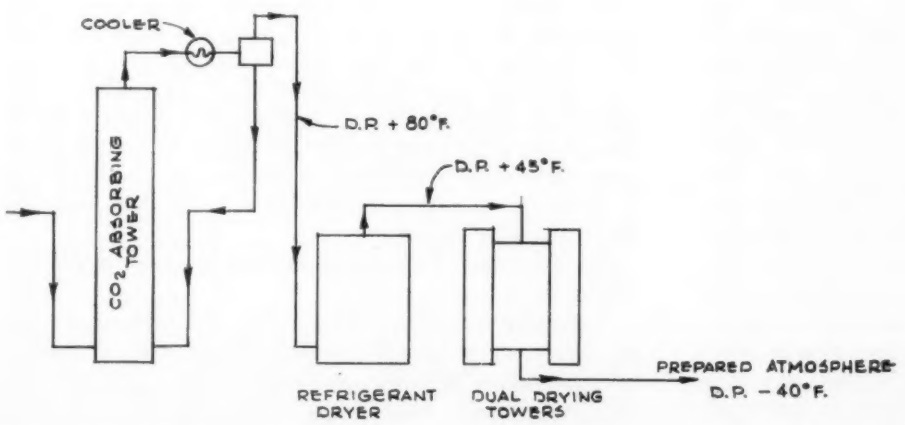


Figure 33 — Schematic of hydrogen-nitrogen generator.



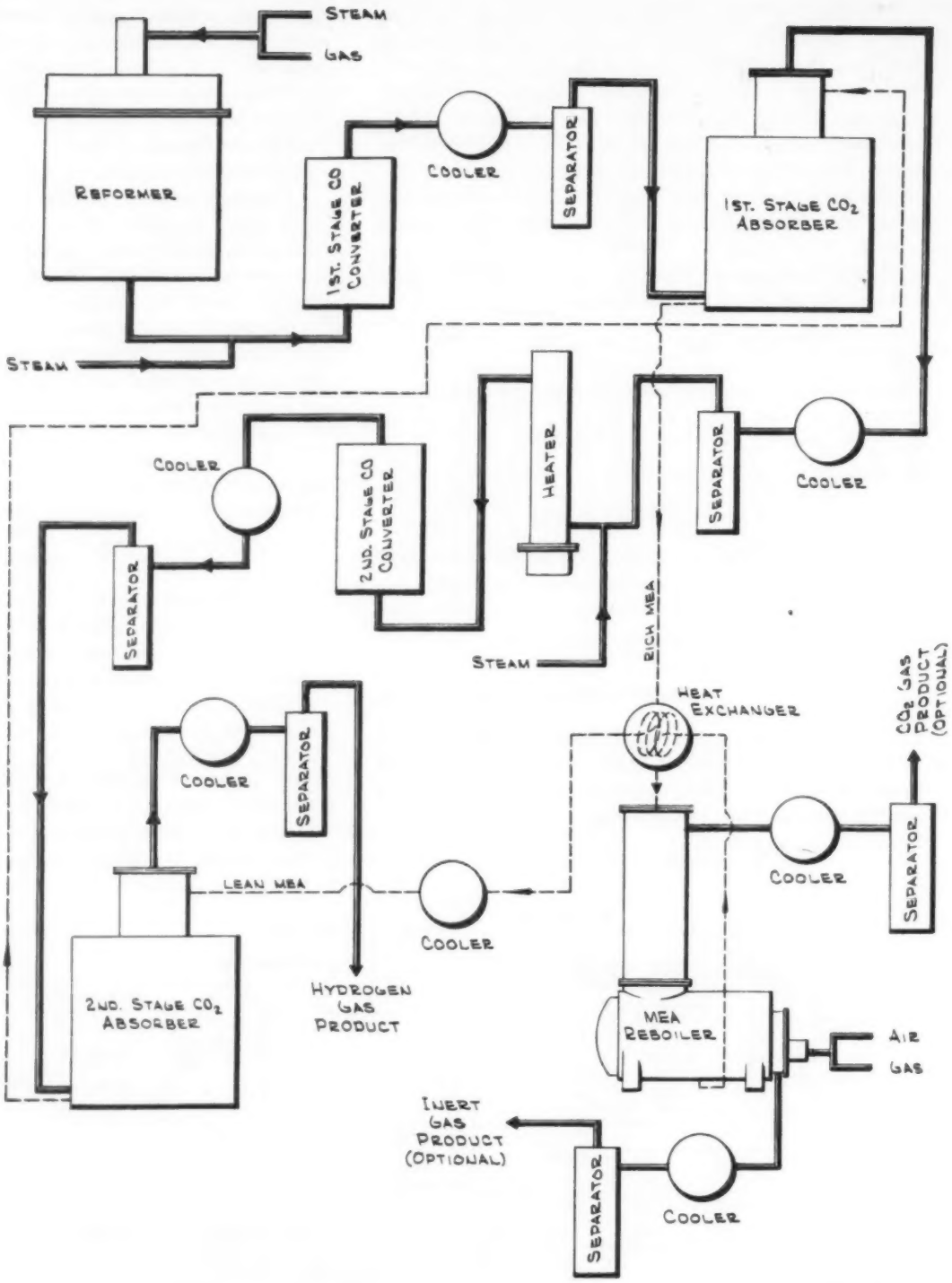


Figure 34 — In hydrogen generator, natural gas is reformed with steel in an endothermic unit.

ture of 1900 to 2000 F. The exit gas temperature from the generator should be slightly above 1850 F. The gases are then cooled to 90 F in an indirect contact cooler and to +40 F in a refrigerant gas dryer. The resultant gas has the following percentage composition: 5.5 CO_2, 9 CO, 13 H_2, 0.2 CH_4, 72.3 N_2, specific gravity of 0.90 and a dew point of +40 F. The schematic flow of this unit is shown in Figure 29. The refrigerant gas dryer is shown in Figure 30. This unit controls the atmosphere gas dew point at +40F (approximately 0.8 per cent $H_2O \times$ volume).

Nitrogen (exothermic type)—This protective gas is produced by burning hydrocarbon gas at approximately 90 per cent aeration, in a fire tube type reboiler. The gases are cooled in a direct or indirect type gas precooler. They are then passed counterflow to a flow of monoethanolamine, in an absorption tower. The monoethanolamine is usually at a concentration of 15 per cent with water and a flow of 1 to 1¼ gpm per 1000 cfhr of atmosphere gas. For simplicity of discussion this solution is usually referred to as MEA. This operation removes the CO_2 from the burned gases. The gas is then passed through refrigerant and desiccant dryers. The resultant percentage gas composition is 3 CO, 3.3 H_2, 93.7 N_2, specific gravity 0.98 and dew point of −50 F or lower.

The schematic flow of this system is shown in Figures 31 and 32.

Hydrogen-nitrogen—This type of protective atmosphere is produced by the same method as the nitrogen gas previously mentioned. The gas from the nitrogen system containing 3 CO, 3.5 H_2 and 93.5

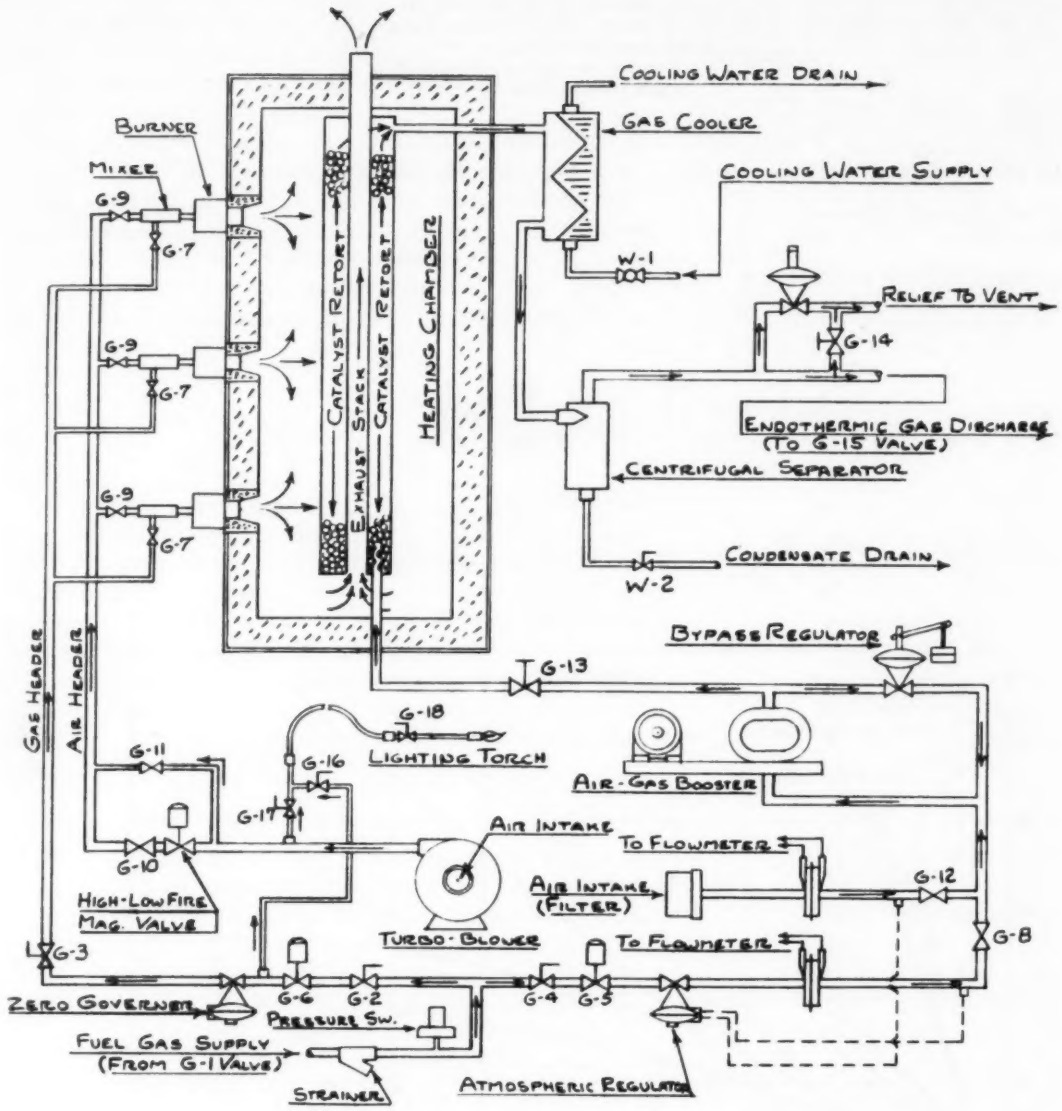


Figure 35 — Schematic flow diagram of endothermic atmosphere generator.

N_2 by percentage is mixed with steam, passed through a preheater, heated to 750 F and then passed over an iron oxide catalyst. This operation converts the CO and H_2O to H_2 and CO_2. The CO_2 is then removed from the gas in a second MEA absorption tower. Next, gases are dried in a refrigerant and desiccant dryer. The resultant gases contain approximately 7 per cent H_2, 93 per cent N_2 and have a dew point of −50 F.

The schematic flow diagram for this unit is shown on Figure 33.

Hydrogen—This protective atmosphere is produced as schematically shown in Figure 34. Basically, natural gas is reformed with steam in an endothermic type reformer. The reformed gas with steam additions is converted, in the first stage converter, from a 50 per cent N_2, 16.7 per cent CO, 33.3 per cent H_2O, mol gas to a 74.76 H_2, 18.3 CO_2, 0.54 CO, 6.4 H_2O, mol percentage gas. After the first stage absorption tower this gas becomes 92.5 H_2, 0.44 CO_2, 0.67 CO, 6.39 H_2O, mol percentage gas. The gas is then reheated in the second stage heater, in the presence of steam, and converted in the second stage converter to a 92.5 H_2, 0.96 CO_2, 0.14 CO, 6.4 H_2O, mol percentage gas. After the second stage absorber this gas is converted to a 96.6 H_2, 0.02 CO_2, 0.15 CO, 6.29 H_2O, mol percentage gas. After drying to −40 F dew point, the final percentage analysis of this gas is 99.81 H_2, 0.02 CO_2, 0.15 CO, 0.02 H_2O by volume.

The CO_2 absorption system on this generator is the same type of MEA system that is used on a standard nitrogen generator.

Endothermic—This type of protective atmosphere is produced by passing a mixture of 2.5 parts of air and 1 part of natural gas over a heated catalyst. This reaction converts the mixture to a gas of the following percentage composition, 20 CO, 40 H_2, 40 N_2, with a dew point of approximately +15 F. The specific gravity of this gas is 0.622.

As the reaction is endothermic two combustion systems are required, one for heating and controlling the combustion chamber to a temperature of 1800 F, and one for controlling the air/gas mixture to the catalyst retort, for producing the protective atmosphere. The schematic flow of this system is shown on Figure 35.

EXPLOSIVE LIMITS OF GENERATED GASES

The question constantly arises, "What are the explosive range limits of generated nitrogen gases?"

To answer, see pages 235 and 236 of "Gaseous Fuels" edited by the American Gas Association (Figure 36)[9].

Using the Le Chatelier mixture rule for gas containing 8 per cent combustibles, 4 per cent H_2 and 4 per cent CO:

Gas	Analysis, per cent	Combinations	Ratio, inert/combustible
N_2	91.0	4 per cent H_2 + 64 per cent N_2 = 68	16.0
CO	4.0	4 per cent CO + 27 per cent N_2 = 31	6.75
H_2	4.0	Both inert/combustible ratios are out of range on Figure 36 indicating gas is not combustible.	
H_2O	0.8		
CO_2	0.2		

For a gas containing 10 per cent combustibles, recheck at 5 per cent H_2 and 5 per cent CO:

Gas	Analysis, per cent			Ratio, inert/combustible	Inflammable limits (From curve, Figure 36) lower	upper
N_2	89	$H_2 + N_2$	5 + 80 = 85	16	74	76
H_2	5.0	$CO + N_2$	3 + 9 = 12	3	55	74
CO	5.0	$CO + CO_2$	1.2 + 0.2 = 1.4	0.166	13	71
H_2O	0.8	$CO + H_2O$	0.8 + 0.8 = 1.6	1	28	77
CO_2	0.2					

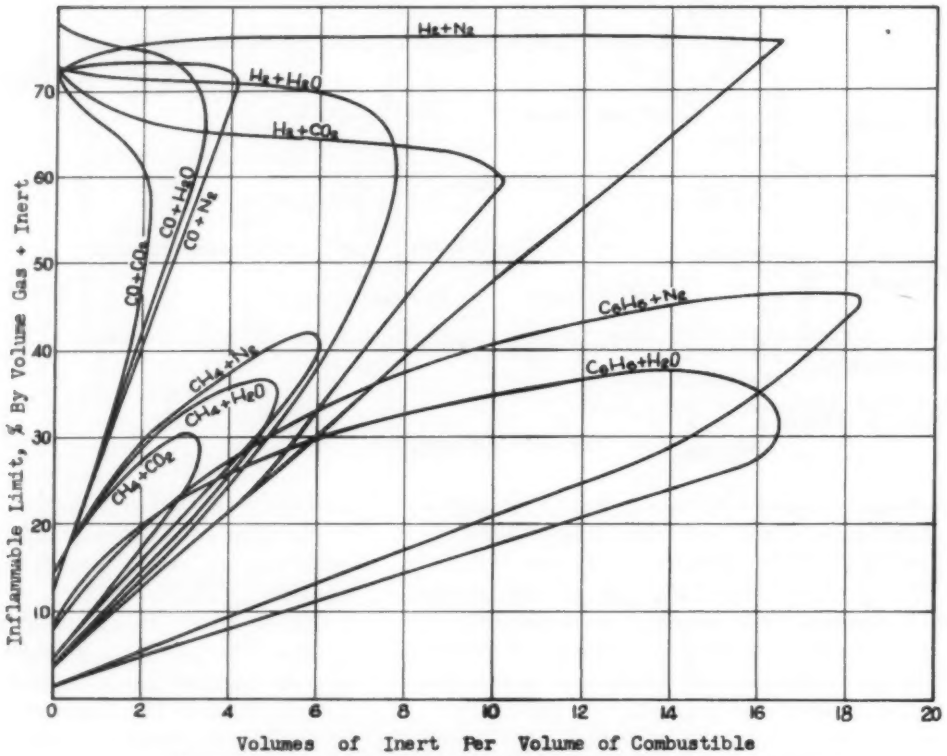
$$\text{Lower limit} = \frac{100}{\frac{84}{74} + \frac{12}{55} + \frac{1.4}{13} + \frac{1.6}{28}} = \frac{100}{1.15 + 0.218 + 0.0107 + 0.057}$$

$$= 65.5 \text{ per cent}$$

$$\text{Upper limit} = \frac{100}{\frac{84}{76} + \frac{12}{74} + \frac{1.4}{71} + \frac{1.6}{77}} = \frac{100}{1.12 + 0.162 + 0.020 + 0.021}$$

$$= 75.5 \text{ per cent}$$

Figure 36 — Chart shows procedure for calculating inflammable limits of various gases.



Inflammable Limits for Combustible Gases Diluted with Nitrogen, Carbon Dioxide, and Water Vapor

The Calculation of Inflammable Limits

1 Gas	2 Gas Analysis Composition	3 Combinations Chosen	4 Total	5 Ratio Inert/Combustible	6 Explosive Limits (Chart 1) Lower	Upper
H_2	12.4%	$12.4H_2 + 6.2\ CO_2$	18.6%	0.50	6.0%	70.5%
CO	27.3	$27.3CO + 53.4\ N_2$	80.7	1.96	39.8	73.0
CH_4	0.7	$0.7CH_4$	0.7	0.00	5.0	14.0
CO_2	6.2					
O_2	0.0					
N_2	53.4					
Total	100.0%		100.0%			

$$\text{Lower limit } \frac{100}{\frac{18.6}{6.0} + \frac{80.7}{39.8} + \frac{0.7}{5.0}} = 19.0$$

$$\text{Upper limit } \frac{100}{\frac{18.6}{70.5} + \frac{80.7}{73.0} + \frac{0.7}{14.0}} = 70.5$$

65.5 per cent of total gas mixture and 33.5 per cent air would be lower explosive limit.

75.5 per cent total gas mixture and 24.5 per cent air would be upper explosive limit.

Any mixture between these limits is inflammable, above or below these limits, noninflammable.

This indicates that 10 per cent combustibles in a gas mixture are in the inflammable range, 8 per cent combustibles are in the noninflammable range.

The purpose of this paper has been to outline, generally, the equipment required and the process to follow, in the use of the gas alloying and annealing system.

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8. "Aging & the Yield Point in Steel," by Gensamer & Law Table 8.
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Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1121 HASIMOTO, H. A.: "Aerodynamic Design of the Open-hearth Furnace," II—Features of Flow in Typical Designs, *Tetsu-to-Hagane*, 1956, Dec., pp. 1102–1105. (Abstract J.I.S.I., 1958, Feb., p. 181.)

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The installation of a 160-in., 4-high plate mill at Sparrows Point meant increased capacity and higher quality, but before the mill was to produce satisfactorily many construction and operating problems had to be solved.

Modernization of the 160-In. Plate Mill

"MECHANICAL FEATURES"

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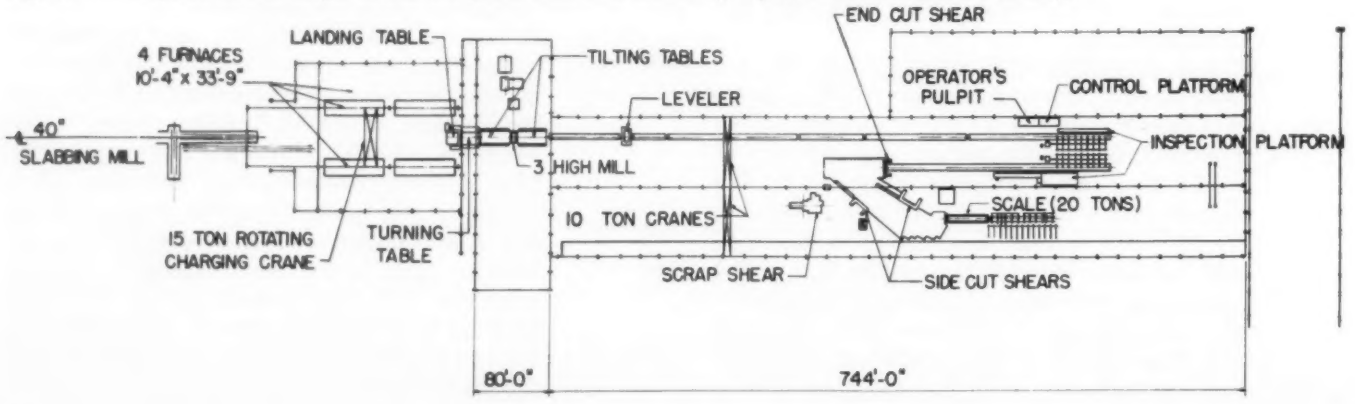
THE plate mill modernization and expansion program at Sparrows Point stemmed from sales department's requirements for better quality products, and for increased tonnages of finished plate. Prior to the conception of this program, the plate mill department operated three separate mills, a 160-in., 3-high, a 110-in., 3-high, and a 60-in. reversing universal mill. Each had its own heating, rolling and finishing facilities. Most of this equipment dated back to World War I; some even farther. The 160 and 110-in. mills could no longer meet some of the new specifications brought about by the addition of new mills and numerous modernized ones. The 3-high mills were unable to consistently roll plates in the lighter thicknesses to a uniform gage, flatness, weight tolerance and finish.

The installation of a 4-high finishing mill in line with the existing 160-in., 3-high mill was considered the best method of getting a better quality product. It was expected to have an output of at least 70,000 tons of finished plate per month. This would be twice the combined output of the original 160 and 110-in., 3-high mills and would eliminate the need for the latter.

In order to achieve the expected increase in produc-

Figure 1 — Layout of the original 160-in. plate mill and auxiliary equipment before remodeling.



at Sparrows Point

tion, modern plate cooling and shearing equipment, including a rotary trimmer, and sufficient finishing and handling facilities were needed.

Engineering was complicated by the need for incorporating as much of the existing equipment and buildings into the finished layout as was economically possible, and at the same time producing an efficient operating arrangement. Construction progress was planned to keep interferences with production to a minimum.

For the sake of clarity a brief outline must first be given of the old 160-in. plate mill as it was before remodeling.

THE 160-IN. PLATE MILL BEFORE REMODELING

The original 160-in., 3-high plate mill shown in Figure 1 had been moved to the plant from Coatesville, Pa., in 1931. This mill, originally a 152-in. mill, together with auxiliary equipment and structural steel buildings, was relocated at Sparrows Point and remodeled into a 160-in. mill with larger diameter rolls and new tilting tables.

This mill produced up to 20,000 tons of finished plate per month. The plate varied from ¼ to12-in.-thickness, in widths up to 120 in. for ¼-in. plates, and up to 150 in. for plates over ¼-in. The handling facilities limited the length to 70 ft and the weight to 38,000 lb.

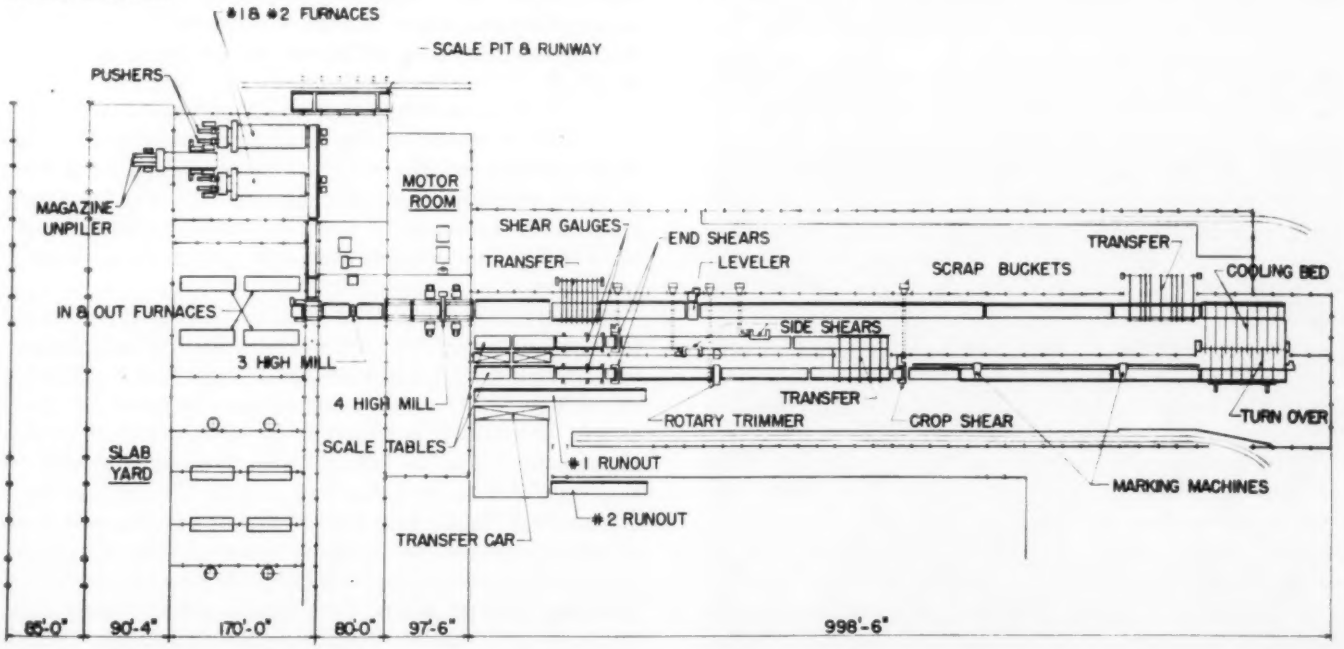
The major units in this mill were four "in-and-out" regenerative-type slab-heating furnaces, one 160-in., 3-high plate mill with tilting tables, one roller leveler, roller tables, a cooling bed and transfer with two plate turnovers, end and side shears, and finishing and shipping facilities.

The plate was produced from rolled steel slabs obtained either from the 40 x 80-in. slabbing mill, which is directly in line with and south of the reheating furnaces, or from the 54 x 106-in. blooming mill. The slabs were transferred to the furnaces directly from the slabbing mill on a shuttle car, or from the blooming mill on narrow-gage slab cars through the slab-storage yards.

The slabs were charged and removed from the furnaces with a 15-ton rotating charging crane. The heated slabs were placed on a landing table for delivery to the mill where they were rolled into finished plate.

After rolling, the plate was hot-leveled on a 7-roller, 2-high, motor-driven leveler, from which it was trans-

Figure 2 — Layout of the modified 160-in. plate mill shows the placement of the new mill, shears, furnaces, transfers and rotary trimmer.



ported over a roller line for cooling and inspecting before shearing.

From the cooling bed and transfer, the plate was reversed in direction and carried to a table where it was laid out to exact size. From the layout table, it proceeded to a hydraulically operated end-cut shear for shearing the front and back ends.

After the plates had been cut to length, they were moved manually over castor beds to two hydraulically operated side shears for side trimming. Upon leaving the castor beds, they were weighed on a 20-ton scale and transported to shipping skids. Four 10-ton cranes handled the plates from the skids and loaded them into railroad cars for shipment. A circle shear located in the shipping aisle produced blanks for the adjacent flanging mill and for flat shipment.

THE 160-IN. PLATE MILL AFTER REMODELING

A layout of the 160-in. plate mill with the 4-high finishing mill and auxilaries after remodeling is shown in Figure 2. This mill produces finished steel plate up to 150 in. wide (or 152½-in. circles), 90 ft long and from 3/16 to 18 in. thick. The capacity is approximately 350 per cent higher than that of the old mill.

Construction of the new mill was started in the late fall of 1955 and completed in March, 1957. The major existing units utilized from the old mill were four "in-and-out" slab-heating furnaces with slab-handling crane, the 3-high mill and some of the roller tables. The major units installed were: a new slab yard, two continuous slab-heating furnaces with magazine unpilers, pushers and conveyors, one 160-in. 4-high reversing mill, mill tables and mill scale pit. Included in the finishing units were a roller leveler, two plate transfers, one cooling bed, one plate turnover, a marking table with two marking machines, two side-cut and three end-cut shears, complete with scrap conveyors, a plate-transfer car and an additional roll grinder. In addition, a new furnace building for continuous furnaces, a new motor room for the 4-high mill, a new shipping building and extensions to the existing processing and finishing buildings were constructed. The slabs for this modernized mill are still obtained from either the 40 x 80-in. slabbing mill or the 54 x 106-in. blooming mill. The majority of the slabs come from the former, the plate mills using approximately 50 per cent of the total production of the slabber. These slabs are processed in the original slab yard, where they may be scarfed or otherwise conditioned for prime plate production, and then transferred to a new and paralleling slab yard shown. This yard is used for storage and scheduling. A small percentage of the 40-in. slabber production is transferred through these yards and charged hot into the four original 160-in. mill "in-and-out" regenerative-type furnaces, which were retained. The larger percentage of the slabs are charged cold into two new continuous-type furnaces.

Slabs from the 54-in. blooming mill are brought into the new slab storage yard on a narrow-gage track system after scarfing and conditioning. A recently completed 460-ft extension to this yard has nearly doubled the available space for slab storage. This yard serves both the 160-in., 4-high plate mill and the existing 60-in. universal plate mill as storage and scheduling areas,

Figure 3 — The magazine unpiler can handle two lifts of slabs.

and provides approximately 85,000 sq ft for storage space.

The arrangement of this area with its 1000 ft of continuous runway lying perpendicular to the four furnace buildings makes it possible to feed all of the "in-and-out" furnaces with any of the three cranes in the new slab yard. However, the two new 160-in. continuous furnaces can be fed by only two of the cranes. These cranes are 40-ton mill-type equipped with rotating tongs for handling slabs.

An existing finger crane runway was extended to handle hot slabs from all furnaces in the 60, 110 and 160-in. plate mills. With this runway arranged parallel to the new slab yard, it is possible to supply both the 60 and the 160-in. mill with hot slabs from either the continuous furnaces or any one of twelve "in-and-out" furnaces.

Conditioned slabs are assembled in lifts in the new slab storage yard in their proper rolling schedule. The slab yard cranes then place the slabs on a magazine unpiler ahead of the continuous furnaces. Figure 3 shows the magazine unpiler and transfer looking from the slab yard toward the charging end of the continuous furnaces. The magazine unpiler can handle two lifts of slabs, the maximum dimensions per lift being 60 x 120 x 36 in.

Slabs are pushed off the unpiler onto a slab transfer by means of motor-driven rack-type pushers. The slab transfer then delivers them to a conveyor line running at right angles to the charging end of the two continuous furnaces where they are spotted in proper locations and pushed into the furnaces in their proper rolling sequence.

The furnaces are of the recuperative, modified 3-zone type, using oil with provision for future addition of coke oven gas. Completely automatic fuel-air ratio, furnace pressure and temperature controls are provided. The effective length from charging door to discharge slope is 80 ft, inside width from wall to wall 23 ft, and the length of soaking hearth 20 ft-4 in. Each furnace will handle two rows of slabs of 12-in. maximum thickness and, 66-in. minimum, and 120-in. maximum length. Heating rate is 128 tphr, or roughly 180 lb of cold steel per hr per sq ft of hearth area covered. The continuous furnaces will heat about 70,000 tons of

slabs per month, or 80 per cent of requirements. The paper "Modern Design of Slab Reheating Furnaces" by H. C. Henschen, 1959 Proceedings AISE, p. 767, describes the design and characteristics of these furnaces in detail.

In addition, the four "in-and-out" furnaces furnish the heating for the heavier sections up to 22 in. thick. These furnaces give the flexibility needed to break in on a rolling schedule to provide rush slabs for completion of orders.

Hot slabs are discharged from the continuous furnaces onto a furnace delivery table which moves them through a section of 1500-psi top-and-bottom descaling sprays before proceeding on to the 3-high mill turn-around table.

The furnace delivery table runs at right angles to the turn-around table, and an overhead slab pusher is used to position the slab on the turn-around table. From this table the slabs proceed to the 3-high 160-in. mill which is now used as a roughing and spreading stand.

The 3-high, 160-in. mill was completely overhauled and a new front table installed. This mill is equipped with 44-in. diam top-and-bottom rolls and a 27-in. diam fluted middle roll. The fluted roll eliminates the use of salt in removing furnace scale and does a good job. Phenolic resin impregnated fabric bearings are used for the top and bottom rolls and brass bearings with babbitt inserts for the middle roll. Besides cleaning, the slabs are also spread to width on the 3-high mill before they are sent to the 4-high mill and finished to gage.

Located approximately 105 ft from the 3-high mill is the new mill, a 4-high 38 and 59 x 160-in. unit shown in Figure 4. Each work roll is driven at 40 to 80 rpm by a 5000-hp, 700-volt d-c reversing motor. This was the first application at Sparrows Point of individual roll drives on a reversing mill. Roller bearings are used for the necks of the work rolls and oil-flooded aluminum bearings for the necks of the back-up rolls. These rolls are balanced by a 3900-psi oil-hydraulic system consisting of a weight-loaded accumulator and two hydraulic pumps. Maximum opening of rolls is 20 in. Mill screws of 18-in. diam and 1-in. pitch are operated by two 150-hp motors under variable-voltage control at a speed of 27½ to 55-in. per min. The mill is also equipped with automatic screwdown control for card-programming of screwdowns and mill speed. This system is employed when the scheduling of sufficient numbers of the same thickness plates through the mill warrants its use.

A strain gage mounted on each mill housing indicates and records rolling pressures to prevent overloading of the aluminum bearings and mill housings. Maximum load recorded thus far has been approximately 3,250,000 lb on each housing, or a total 6,500,000 lb roll-separating force on the mill. This is well within the allowable mill design load of 9,000,000 lb. These measured loads have served as a check on operating draft practices and have permitted the operators to revise previous pass patterns.

There are tapered roll turn-around tables located on both the front and rear of the 4-high mill. Front and rear mill tables have adjustable side guards which are manually controlled or may be interlocked with the reversal of the mill. The rolls in the turn-around tables and the front and rear mill tables are individually driven, eliminating line shafts.

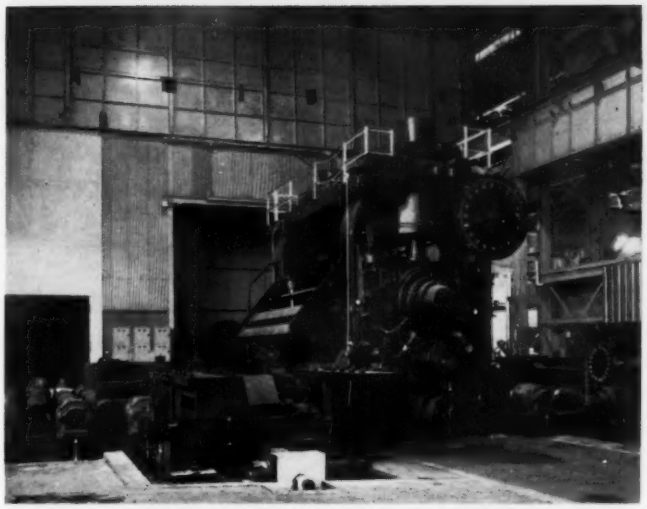


Figure 4 — The new 160-in. mill has individually driven work rolls, each turned by a 500-hp. motor.

Approximately 292 ft from the 4-high mill is a 2-high leveler containing eleven 13-in. diam rolls and a pair of 16-in. diam pinch rolls. This unit flattens plates from 3/16 to 6 in. thick.

Mill scale is removed by 1500-psi hydraulic sprays. Spray stations are located at the continuous furnace runout table just ahead of the slab pusher, the 3-high mill and the 4-high mill.

The mill scale is flushed into a sluiceway which starts at the leveler and flows back under the mills, mill runout tables and furnace runout tables and into the scale pit. Steam and low-pressure water sprays are installed at the leveler. Steam is used to cool thin plates; water to cool plates over 3/8 in. thick.

Approximately midway between the 4-high mill and the leveler is a 45-ft wide heavy-plate transfer for delivering plates to the process building for normalizing.

After leveling, plates proceed down a runout table for approximately 600 ft where plates thicker than 1½ in. are taken to the process building on a 72 ft transfer table. Plates 1½ in. and under pass over the transfer table to a 96-ft cast grid cooling bed which may be operated as a unit or as two separate beds. Figure 5 is a view looking from the cooling bed toward the leveler.

Figure 5 — Looking towards the mill from the end of the cooling beds gives an indication of the length of the mill tables.

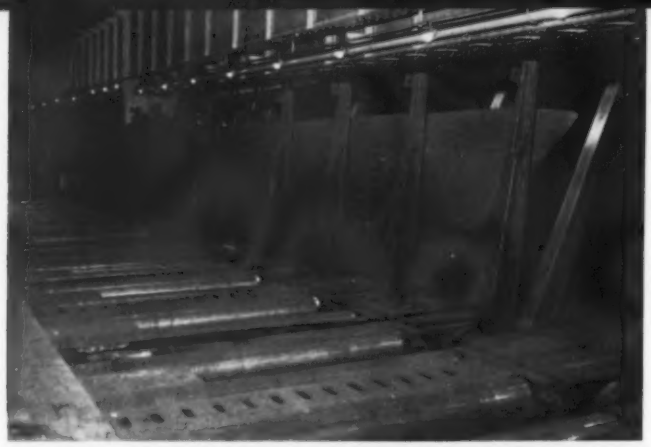


Figure 6 — The plate turnover is used to aid in inspection.

Figure 7 — A manually controlled machine marks length and width lines on each plate.

Figure 8 — Plates up to ½ in. in thickness and 140 in. in width are sheared by a rotary trimmer.

Figure 9 — Plates over ½ in. in thickness and 140 in. in width are sheared at one of two hydraulic side shears.

At the opposite side of the cooling bed is a plate turnover which is used for inspection purposes. This turnover can also be split and used in equal parts in the same way as the cooling beds. Figure 6 shows the turnover in operation.

Plates leave the turnover and proceed to a 272 ft marking table where they are marked and stamped. Width and length lines are marked on the plates with a manually controlled machine. The plate-marking operation is shown in Figure 7. From the marking table the plates are moved to a self-contained oil-hydraulic 160 x 1½-in. crop shear. From this point plates ½ in. and under in widths up to 140 in., continue in line to a rotary trimmer (Figure 8) equipped with scrap choppers and plate-handling equipment for alining the plate. In the near future this trimmer will be altered to shear ¾ in. plate.

Plates above ½-in. gage and over 140-in. wide are transferred to a side shear line where plate-handling equipment positions them at the two 160 x 1½-in. self-contained oil-hydraulic side shears equipped with a scrap cut-off knife. The one shown in Figure 9 also has a width gage.

The rotary-shear line and the side-shear line both have an end-cut shear equipped with plate-handling devices for squaring up plates and shearing to length by means of a length-shear gage. Side and end scrap is conveyed to scrap choppers and then to scrap buckets located in pits in the process building.

Leaving the end-cut shears, plates are checked for length, width, and gage. They are then weighed, picked up by stacking cranes and piled into lifts for shipping from the 160-in. shipping building; or they may be placed on a 100-ton, 87-ft roller table transfer car and taken to an adjacent shipping building, formerly the 110-in. mill building.

The 160-in. mill shipping building is equipped with four 25-ton cranes, the adjacent 110-in. mill shipping building with three 15-ton cranes.

In addition to shipping, the 110-in. mill area is equipped with end and side-cut shears for salvaging operations, and two shears for circle cutting.

The process building houses the normalizing, shot-blasting and flame-cutting operations, as well as the shipping facilities for these products.

The magnitude of the electrical equipment in this mill may be judged by the fact that over 400 motors were installed, exclusive of crane motors, and over 500 ft of control panels and control centers were provided.

PROBLEMS OF INSTALLATION UNDER OPERATING CONDITIONS

Many engineering, electrical, construction and operating problems were encountered in the modernization of the mill. Close cooperation by all was necessary in order to hold the mill interferences to a minimum and maintain maximum production. Figure 10 is a composite layout of the new mill and auxiliaries superimposed on the original layout to show where existing equipment interfered with the installation of the new equipment. Major problems were encountered at the 4-high mill, front and rear mill tables, run-out tables, leveler, transfer to side-shear line, side shears, tables through

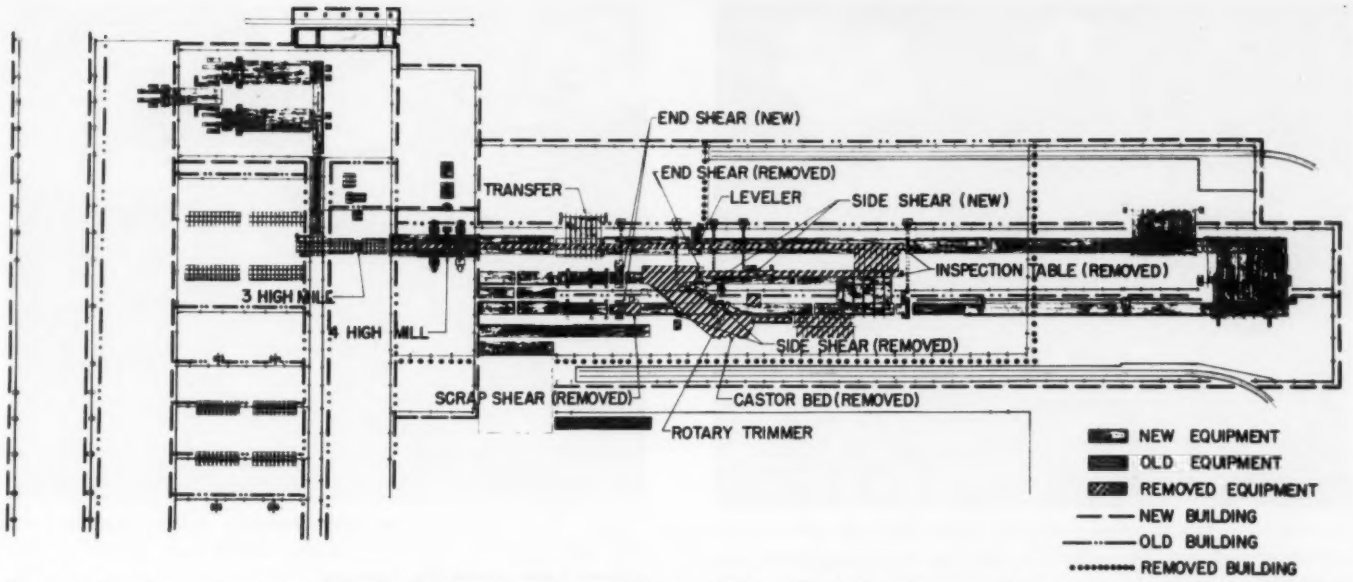


Figure 10 — A superposition layout of the old and new 160-in. plate mills indicates areas of construction difficulties.

side shears, rotary trimmer and trimmer run-out table.

The most complicated problem was to erect the new 4-high mill on the roller line of the old mill, at the location of the original leveler. In order to solve this problem a temporary leveler was installed further along the line and the original leveler was removed; piles were then driven on both sides of the original roller line and steel beams laid across on the piling to support the table beams while the mill continued in operation. With the roller line thus temporarily supported, excavations were dug for the foundations for the finishing stand, (Figure 11), bearing piles were driven and the necessary concrete was poured. The mill shoes and housings were installed and plate production continued with the hot plates passing through the new mill housings (Figure 12). A similar procedure was followed at other points along the roller line, to allow excavation and preparation of foundations for mill run-out tables, leveler, oil cellar and control houses to proceed without loss of production of the old mill.

Even with our best efforts it was not possible to complete the construction work without a mill shutdown. Construction crews worked seven weeks to install all the equipment that could not be installed during mill operations. Figure 13 shows construction work during the mill shutdown.

Another unusual step in the construction procedure was the jumping of two previously erected cranes over two new cranes in the shipping building. This was done to facilitate the erection of two new cranes and the dismantling of one of the older cranes in this building without disrupting shipping operations. As part of this procedure three bays of roofing were omitted in the new building extension. After the new cranes were erected, one of the existing cranes was run into the new section and positioned under the open roof. Two 80-ton caterpillar cranes were positioned on one side of the runway and two 50-ton cranes on the opposite side. The trolley was blocked on the crane bridge girder rails adjacent to the 80-ton cranes for proper distribution of the 168-ton load. It required just twelve minutes from the start of hoisting operations to lift the crane high enough for the new cranes to pass underneath (Figure 14). This operation was repeated for the second crane.

Figure 11 — Temporary piling supported the original mill tables while foundations for the new mill were prepared.

Figure 12 — The new housings were installed while the existing mill continued to roll.

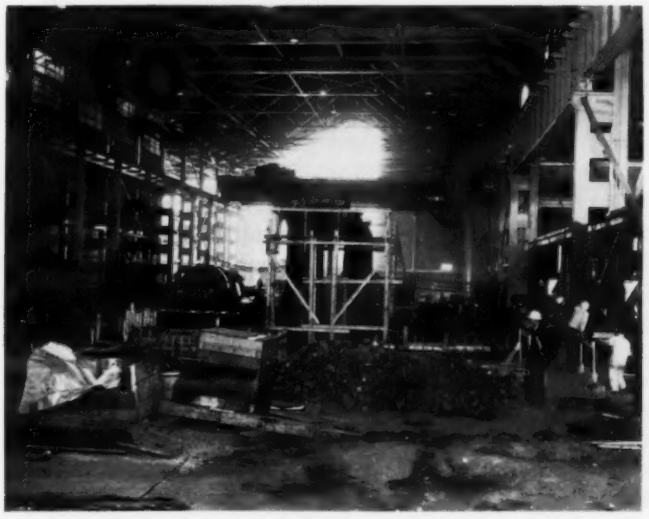


Figure 13 — During the required shutdown all equipment which could not be installed during mill operation was installed.

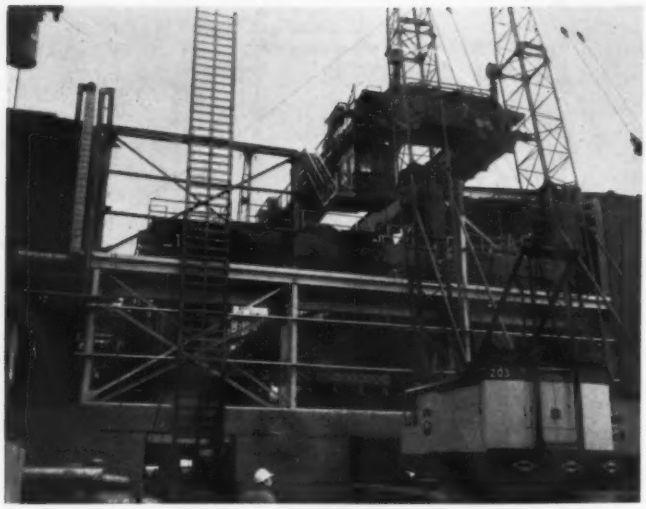


Figure 14 — Two 80-ton crawler-type cranes are shown supporting one end of a crane while two cranes move underneath along the runway.

The entire operation took less than one hour; during the procedure the raised cranes were maintained in a nearly level position.

The expectations for the new mill were not immediately realized. Numerous mechanical difficulties were encountered over a period of time. The difficulties of training and acquainting the mill personnel with the operation and functioning of the new equipment had to be overcome. After years of production experience on the old equipment, involving heavy bullwork and physical exertion, all the old training had to be undone and new skills, involving the manipulation of new sensitive controls, had to be learned. However, even with these early difficulties, the new mill in its first month of operation produced 18,253 tons of plates.

To date the new mill has produced nearly 55,000 tons per month, 20,000 tons per month more than the old 160 and 110-in. plate mills combined! The quality of product and daily production have equaled expectations.

"ELECTRICAL FEATURES"

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Bethlehem Steel Co.,
Sparrows Point, Md.

EARLY in 1955, Bethlehem Steel Co. decided to modernize the 160-in. plate mill at the Sparrows Point plant. This decision was based on the need for larger tonnage and better quality plates than could be produced on existing facilities. In order to accomplish these objectives, it was necessary to replace the antiquated processing equipment with the most modern plate mill machinery available. The installation was completed in the spring of 1957. The features of the electrical equipment required to drive, control and operate the new machinery is the subject of this paper.

The mechanical equipment was designed to make plates of consistently good quality with accurate dimensions at high production rates. The result is a highly mechanized operation that eliminates the heavy manual operations previously required in the processing of plates. The extent to which this was accomplished can best be illustrated by the fact that over 400 motors, exclusive of crane motors, were installed in the area where 30 were previously used. The electrical apparatus was designed to complement the mechanical equipment and to allow the operating personnel to realize the full benefits of the mechanization.

The power system, main drive motors, main mill auxiliaries, automatic screwdown control, auxiliary drives, communications systems and other associated electrical equipment will be described in that order.

POWER SYSTEM

Previously only 6900-v 25-cycle primary power was available in the plate mill area. In accordance with present plans to eventually replace all 25-cycle equipment in the plate mills with 60-cycle equipment, it was decided to feed any new loads resulting from this project through the 6900-v 60-cycle primary system. The power requirement was expected to average 7000 kw at 90 tphr with a maximum of 11,500 kw at 150 tphr based on an estimated increase of 28,000 connected hp. Ample power was available at the blooming mill sub-station.

To transmit the required power, two 1,192,500-cm, ACSR feeders were run on existing towers from the blooming mill sub-station to the 160-in. plate mill motor room, a distance of about half a mile. These cables are provided with pilot wire and overcurrent protection, lightning arresters, and overhead ground wires. At present the mill can operate on one cable; however, two cables were installed to provide flexibility, continuity of service, and extra capacity for anticipated future loads.

Due to later additions, the total increase in connected hp is now about 31,000 hp. The original 4500-hp motor in the three-high mill and a few unchanged auxiliaries are still supplied from the 25-cycle system. The combined 25 and 60-cycle power consumption averages 22.5

kwhr per ton for the main drives and 54.5 kwhr per ton for the auxiliaries.

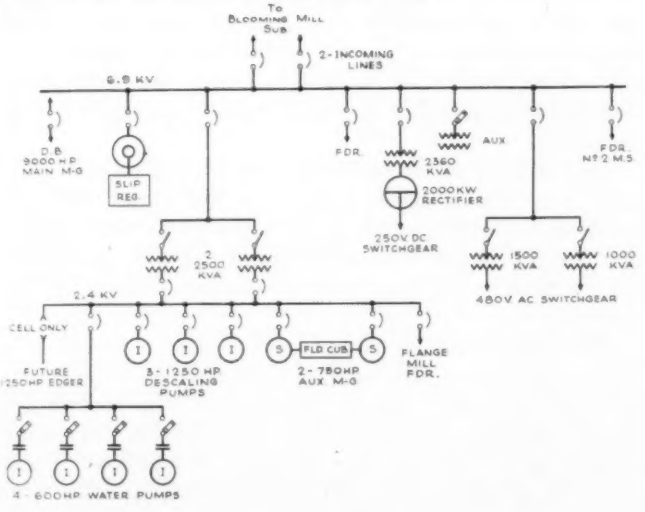
Referring to Figure 1, the two incoming 60-cycle lines feed the 160-in. plate mill 6900-v switchgear which consists of nine 1200-amp circuit breakers. The outgoing lines feed the 9000-hp main motor-generator set, two 2500-kva, 6.9/2.4-kv transformers, one 1500-kva and one 1000-kva 6900/480-v transformers, one 2360-kva rectifier transformer, and a recently added feeder to No. 2 machine shop. One circuit breaker is used for dynamic braking of the main motor-generator set and one extra breaker was provided for future conversion of existing 25-cycle equipment to 60-cycles.

Present plant practice is to use 2400-v for motors in the general range of 300 to 1500-hp. Therefore, the three 1250-hp descaling pumps, four 600-hp water pumps and two 750-hp auxiliary motor-generator sets are supplied through the two 2500-kva 6.9/2.4-kv transformers and associated switchgear. Circuit breakers are used to start all motors except the 600-hp water pumps. For economic reasons and because of frequent starting, the 600-hp motors are controlled by high-voltage contactors with current limiting fuses. An extra circuit breaker for a planned flanging mill feeder and one empty cell for a future 1250-hp edger were also installed.

The power from the two 6900/480-v transformers, totaling 2500-kva, is distributed to the various motor starters, motor-control centers and lighting transformers. Each feeder is protected by a 1200-amp circuit breaker. Numerous 480-v receptacles for portable equipment, such as welders and fans, were installed throughout the mill area. The total connected load on the 480-v system is about 4400-hp, including lighting. A tie line to the 40 x 80-in. slabbing mill provides emergency power for lighting, sump pumps, etc.

D-c power for cranes and constant-potential auxiliaries in the 4-high mill, processing, finishing and shipping areas is derived from a 250-v 2000-kw rectifier. The connected load on the rectifier is about 8800-hp. A connection to the plate mill-blooming mill tie line will furnish limited d-c power in case the rectifier is out of service. Some difficulty was experienced in paralleling the rectifier with the tie line, therefore the tie breaker is normally open. Usually we operate rectifiers in parallel

Figure 1 — Two incoming lines feed the 160-in. plate mill switchgear and the No. 2 machine shop.



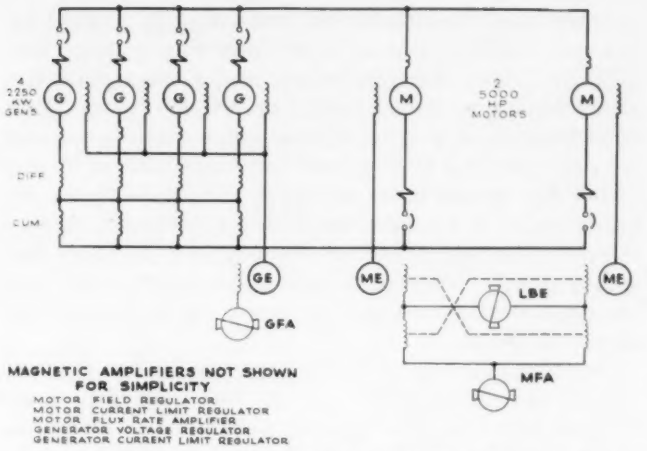


Figure 2 — The four generators are load balanced by an equalizer bus which also permits isolation of a faulty unit.

with motor-generator sets to absorb regenerative currents; however, in this case we have had no problem operating the rectifier as an independent unit

Existing equipment was utilized to supply 250-v d-c power to the new equipment in the furnace and slab yard area.

MAIN DRIVE

The two work rolls of the 4-high reversing mill are individually driven by a 5000-hp, 40/80 rpm, 750-v motor on each roll. This was the first application at Sparrows Point of individually driven work rolls on a large reversing mill. Use of separate drives not only eliminates the conventional pinion stand but has the added advantage of permitting the adjustment of the speed relationship between the two work rolls. The speed matching adjustment will compensate for small differences in roll diameter and also controls the amount the head end of the plate is turned up. Another innovation for us was the use of forged flange couplings on the main motors. The coupling is an integral part of the shaft thus eliminating failure due to excessive stresses in the coupling and shaft keyways. This type of coupling shortens the overall length of the motor and it is stronger than any other portion of the drive shaft. Body-bound bolts and a face key form the connection between the motor half-coupling and the mill spindle half-coupling.

At full field, or 40 rpm, the 10,000-hp twin-drive will develop an "every ingot" torque of 2,950,000 lb-ft and an emergency torque of 3,610,000 lb-ft, the figures being respectively, 225 per cent and 275 per cent of the rated continuous torque of 1,313,000 lb-ft. As would be expected at 80 rpm, under weak field conditions, the rated torque drops to half of the 40-rpm value. At weak field the significant fact is that the "every ingot" and emergency torques available drop to about 42 per cent of the 40-rpm value because of lessened commutating ability. Often the maximum available torque is not utilized on a mill of this type because of a desire for high speed operation. To aid the operator in getting maximum torque, a foot switch giving full field was provided for use on heavy drafts. This eliminates the necessity for the operator to feel the points of the master controller to find the full field position.

Power for the reversing motors is supplied from a

flywheel motor-generator set consisting of a 9000-hp, 514-rpm, 6600-v wound-rotor induction motor, four 2250-kw, 750-v d-c generators, and a steel plate flywheel having a stored energy of 250,000 hp-sec. Past consideration of a synchronous-motor motor-generator set drive for this type of mill indicated that at least a 12,000-hp synchronous-motor would have been required here. A wound-rotor motor was chosen because the power system would not support the peak loads that would result from a synchronous-motor. The slip regulator for the wound-rotor motor limits the peaks to about 6000-kw.

As shown in Figure 2, the four generators and two motors are all paralleled on the 750-v d-c bus. Load balance between generators is accomplished by means of an equalizer bus between the common points of the differential and cumulative series fields. With this arrangement, should one generator fail, it can be isolated electrically and rolling can continue at a reduced rate until the faulty unit is repaired. The speed matching previously mentioned and load balance between top and bottom motors are obtained through a load-balance exciter.

The main drive control is arranged to also include the following functions:

1. High rate of acceleration and deceleration and fast reversal. It should be noted here that normally we do not tune the regulators to get the fastest reversal possible. It has been found that the mill equipment tends to suffer and the operators do not have sufficient time for setting the screws between passes if the reversal is too fast.
2. Six definite speed points in each direction controlled by the operator with a mill type master switch. A selector switch and foot switch provide over-riding speed limits.
3. Selection of either creep or suicide of roll speed between passes. Creeping of rolls permits uniform roll cooling whereas a definite stop is obtained with suicide.
4. Jogging of each motor separately to aline spindles during roll changes.
5. Regulation of maximum motor current to 150 per cent during regenerative braking and to 200 per cent load limit during field weakening.
6. Full protection of motors and generators. One particular item of interest under this heading is the ground-detection scheme. The conventional method of detecting grounds on main drives has been to connect a sensitive voltage relay between the midpoint of a bus-voltage divider and ground. Investigation showed that under certain conditions a grounded armature winding would cause an a-c voltage to be impressed on the ground relay. The type of relay used will not respond to a-c voltages, therefore, we now use a full-wave rectifier in conjunction with the relay to insure detection of grounds manifested by a-c voltages.

MAIN MILL AUXILIARY DRIVES

The main mill auxiliaries consisting of the screwdowns, approach table, front and rear mill tables, feed rolls and runout table are controlled by variable-voltage systems. Only one mill auxiliary function, the side guards, utilizes constant potential control. The approach-table rolls and part of the rear mill table rolls are tapered to allow turning the plate at either of these locations. Alternate rolls in these table sections are grouped together control wise to permit turning. The control of the front and rear tables is coordinated with that of the main mill drive to provide for automatic reversal of the tables and short stroke operation of the side guards with the reversal of the mill. This arrangement relieves the table operator of a large number of master switch manipulations.

All of the rolls in the tables noted above are individually driven. This is our first application of individual table roll drives to a reversing mill, except on feed rolls. Eighty 550-v mill-type d-c motors, operated at reduced voltage for proper speeds, are used on the tables immediately associated with the main mill. This completely eliminates line shafts and their inherent difficulties in this type of service. The only problem encountered with individual drives has been the tendency of a roll to stall occasionally on a bent slab. This has been largely overcome by removing the thermal trip from the circuit breakers protecting each motor.

All of the variable-voltage control systems for the auxiliaries employ a two-stage magnetic amplifier-rotating unit regulator to provide current limit acceleration and deceleration and voltage regulation.

AUTOMATIC SCREWDOWN CONTROL

To obtain plates with more uniform thickness and metallurgical properties and to reduce operator fatigue, card programmed automatic screwdown control was installed on the 4-high mill. Either manual or automatic operation may be selected. Usually an order for a small number of plates is rolled manually and the automatic control is reserved for large orders. This method of utilizing the equipment is dictated somewhat by the need to change cards frequently on small orders. However, occasional manual operation is desirable to maintain the operator's skill.

A short description of the screwdown drive and control which is common to both manual and automatic operation would be in order. The screws are driven by two 150-hp, 230-v mill-type shunt motors with the fields reconnected for 115 v to permit field forcing while running for maximum torque. The motors are operated up to double voltage for high speed operation. Each motor is provided with a 19-in. shunt brake arranged with brake forcing. Magnetic clutches permit leveling of the rolls. Power is supplied to each motor by a 150-kw, 250/500-v differentially-compounded generator. The generator voltage regulator is controlled by a signal from the master switch or by a signal from the automatic equipment, depending on the method of operation being used.

The automatic screwdown control equipment consists of a control panel located in the motor room; a position detector geared to the screwdown drive shaft; and a card reader, zero adjustment cabinet, pass indicating lights and miscellaneous devices located in the mill pulpit.

The various roll openings used to reduce a slab to a finished plate are programed on an IBM card. A maximum of 15 passes can be programed. The screws are positioned with an accuracy of ±0.005-in. for openings from 0.00 to 9.99-in. As the mill will open to about 20-in., however, it was not considered necessary to pro-

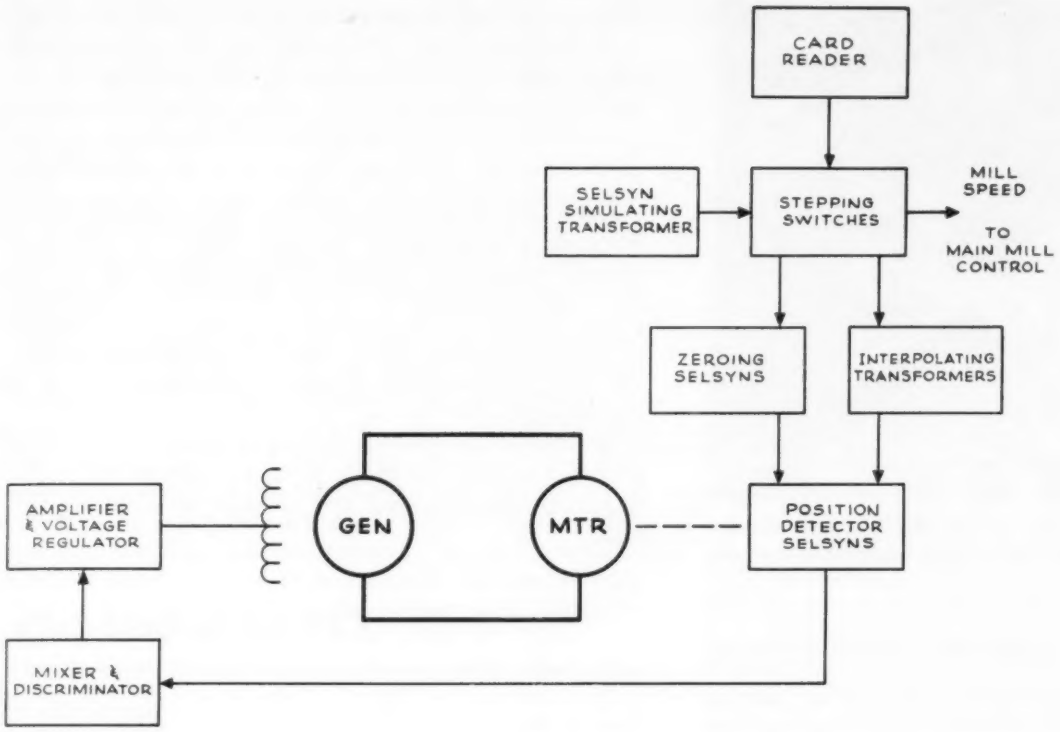


Figure 3— Screwdown position regulation is automatically controlled by the illustrated circuit.

vide automatic control for the infrequent occasions when a slab of over 10-in. might be rolled. Normally slabs are spread for width on the 3-high roughing mill and are delivered to the 4-high mill about 2½ or 3-in. thick for finish rolling to thicknesses down to 3/16-in. Usually seven to eleven passes are taken on the finishing mill.

In addition to programming the screw settings, the automatic equipment includes provisions for determining the maximum mill speed for each pass. This means that the torque required for heavy drafts and the speed needed on long finishing passes can be programed to utilize the main-drive motor capacity to the fullest.

The operator selects the appropriate card for the particular slab size and finished size to be rolled and inserts the card in the card reader. The screws are brought to the first pass position by using the reset pushbutton. The screw position advances to the setting for each succeeding pass when the next pass pushbutton is depressed. Operation of the next pass pushbutton after the last pass brings the screws to the first pass position.

Originally the zero adjustment was merely intended to compensate for changes in roll diameters. The operators have found it possible to reduce the number of cards required by showing a zero last pass opening on the card and setting the finished thickness by means of the zero adjustment.

Under automatic operation the screwdown motors, generators, voltage regulators and automatic equipment become a position regulator as shown in Figure 3. The card reader sets up stepping switches that select voltages from the selsyn simulating transformer. These voltages represent the desired position. The position detector consists of three selsyns geared for one, one tenth and one hundredth of a revolution per in. of screw travel. The selected voltages correspond with the selsyn stator voltages that will produce zero rotor output when the rotors are in the desired position. Any difference between the actual position and the desired position results in error signals on the rotors of the position-detector selsyns. The error signals are combined in the mixer and converted in the discriminator to give a d-c signal of magnitude and polarity determined by the amount and direction of the error. The d-c signal controls the amplifier and generator voltage regulator to drive the motor and selsyns to the desired roll position. The zeroing selsyns modify the voltages from the stepping switches to compensate for changes in roll diameter and the interpolating transformers introduce voltages in the rotor circuits to permit fine positioning.

AUXILIARY DRIVES

The auxiliary drives such as the tables, leveler, transfer chains, turnover, positioning equipment, trimmer, scrap shears and scrap conveyors in the finishing area use conventional d-c constant potential control. The plate turnover is an interesting example of semi-automatic operation. Previously two controllers were used to independently operate the two sets of turnover arms. This required considerable skill on the part of the operator to prevent dropping plates and damaging equipment. To overcome this problem both sets of arms are controlled by one master switch. Limit switches insure proper position of the arms at each step of the turnover operation, especially during the transfer of the plate from one set of arms to the other. The arms stop at the end of their upward travel and the operator reverses the master switch to lower the plate after he sees that it is not balanced on edge.

The five plate shears have integral hydraulic systems each powered by a 200-hp, 300-rpm wound-rotor motor. The motors run continuously but are only loaded during the cutting cycle. The electrical control of the hydraulic valves is arranged to start the cutting cycle during the proper part of the pump stroke and to prevent double stroking on a single cut.

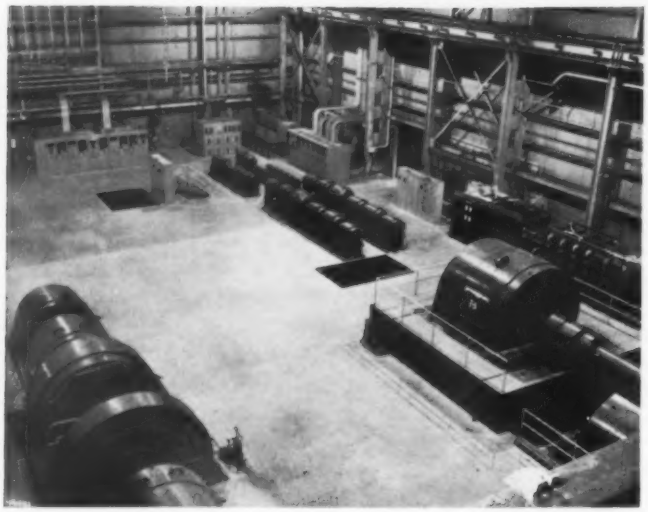


Figure 4 — Motor room view shows the flywheel motor-generator set, main drive motors and associated switchgear.

COMMUNICATIONS SYSTEMS

Practically all of the operators in this mill are located in widely separated enclosed pulpits. This necessitated the use of signal light and loud-speaker systems for communications between operators whose efforts must be closely co-ordinated. In all, there are five separate loud-speaker systems and three signal-light systems in the mill area.

One closed-circuit television system is used to check identifying marks on the plates before they are distributed to the shipping building. The location of the marks on the plates with respect to the checkers made the marks difficult to read by direct sight. As neither the marks nor the checkers could be relocated, we resorted to television, with excellent results.

OTHER EQUIPMENT

Nearly fifty electrically controlled oil and grease systems were installed. These automatic and semi-automatic systems insure proper lubrication of the machinery at all time. The waste so often associated with manual lubricating methods is eliminated.

The new buildings erected during this project were designed without windows or skylights to preclude costly maintenance. Such buildings require higher level lighting than previously used in mill buildings. Because of the higher lighting loads involved, we chose 440-v mercury vapor lamps for all overhead lighting. In order to comply with the National Electrical Code requirement that lighting circuits not operate at over 300-volts above ground, 480/480-v, delta-wye isolating transformers with a grounded neutral were installed.

Motor room ventilation is an important item. A relatively cool motor room is maintained by using a downdraft system through the main machines. The main motors and motor-generator set require 190,000 cfm of air. Of this, 140,000 cfm passes through coolers and returns to the basement plenum chamber where it mixes with the make-up air. The remaining 50,000 cfm is discharged outside or used for motor-room heating, depending on the weather. An electrostatic filter and associated fans furnish up to 170,000 cfm of clean make-up air to the basement. About 57,000 cfm of air is withdrawn from the basement for mill auxiliary motors and the rest passes up through gratings to the main room.

SUMMARY

Some idea of the magnitude of this electrical installation may be given by the facts that over 500 ft of control panels and control centers, 400,000 ft of conduit, and 3,000,000 ft of conductors were required. Practically all of the control equipment was installed in the main-motor room and seven control houses. Six of the control houses are located underground to conserve space.

It is believed that the electrical equipment selected and the manner in which it was installed are major factors in the successful and efficient operation of this mill.

Discussion

PRESENTED BY

E. C. PETERSON, Vice President, Rolling Mill Equipment Div., Birdsboro Corp., Birdsboro, Pa.

J. C. SCHAAKE, Chief Draftsman, Engineering Dept., Bethlehem Steel Co., Sparrows Point, Md.

THOMAS MASSEY, JR., Assistant General Electrical Foreman, Sheet, Tin and Strip Div., Bethlehem Steel Co., Sparrows Point, Md.

R. A. HAMILTON, Application Engineer, General Electric Co., Collingdale, Pa.

R. McMICHAEL, Assistant Manager Steel Plants, Lukens Steel Co., Coatesville, Pa.

R. R. FAYLES, Manager Steel Plants, By Product Steel Div., Lukens Steel Co., Coatesville, Pa.

F. W. WAGNER, Superintendent, Plate and Flanging Mills, Bethlehem Steel Co. Sparrows Point, Md.

C. W. RITTERHOFF, Assistant Superintendent, Plate and Flanging Mills, Bethlehem Steel Co., Sparrows Point, Md.

H. R. KNUST, Assistant General Manager, Bethlehem Steel Co., Sparrows Point, Md.

E. C. Peterson: I would like to ask the authors two questions: One concerns the range of plates handled on the hot leveler, which was stated as being from $\frac{3}{16}$ to 6 in. That seems like a wide range, and I wonder whether there is any mechanical provision to change the center distance between the rolls to accomplish this range, or whether satisfactory leveling is obtained with a fixed center distance.

My other question concerns the automatic screw-down. These units have been the subject of much interest recently, and most new installations seem to be equipped with one form or another of them. I was interested in the fact that the automatic unit here is apparently not used on short orders. I presume that this is a result of the time necessary to install a card in the card reader, and make whatever other

adjustments are necessary. I would like to inquire what this time delay would be.

J. C. Schaake: In answer to Mr. Peterson's first question concerning range of plates handled in the hot leveler, the leveler was designed as a $\frac{3}{16}$ to $1\frac{1}{2}$-in. unit with no provisions for changing the horizontal spacing of rolls. Plates thicker than $1\frac{1}{2}$ in. are reasonably level and hotter than the thinner plates as they come from the mill and can be satisfactorily leveled up to 6 in. Mr. Massey will answer Mr. Peterson's second question.

Thomas Massey Jr.: As to the automatic screwdown control not being used on small orders, the time to insert a card into the reader is negligible. However, the time to select that card is the problem. There are frequent changes in the scheduling of orders, and as a result it has been found impractical to have the operator take time to select the card that would be suitable for a few plates. The actual motion of putting the card into the reader is an operation requiring five seconds at the most, but the selection of that card might be considerably longer.

R. A. Hamilton: I would like to clarify one point which Mr. Massey made in his paper, concerning the overload rating of these motors. I believe it was stated that these motors are limited to 200 per cent during field weakening. This is correct for the last speed point, but actually the current limit is tapered as a function of field weakening.

At full field the motors have a 225 per cent limit, which tapers off to 200 per cent at the extreme weak field speed point. This of course is the frequent "every ingot" capability. The bus overload relays are set at 250 per cent current and the circuit breaker setting is at 275 per cent.

Mention was made of the 550-v armature individual table roll motors used with 90-v generators in order to obtain the necessary speed.

Since this mill was ordered a new line of slow speed table roll motors has been developed which have special 230-v armatures, allowing the motors to get down to the required speed. This means that standard 250/500-v generators can be used to power these drives. I believe the new slabbing mill at Sparrows Point utilizes these motors.

Mr. Massey described the programming control used on the plate mill. This was one of our first programming controls, utilizing our new standard method of selsyn position feedback. It was built to position the rolls in increments of 0.005 in. from 0 to 9.99 in., with a positioning accuracy of plus or minus 0.005 in.

We experienced quite a bit of difficulty in getting this performance, owing to the variations of friction in the screw. This friction would vary over a very wide range, and was not even constant at a particular screw opening.

The problem was finally solved by utilizing an automatic null vernier system, which pulses the screwdown regulators as they approach a null and tended to be stalled.

Many hardware advances have been made since this programming control was installed, and we now utilize all static components except for test circuits.

As these mills become more automated it takes longer and longer to place them into full production. New problems and functions crop up which were not anticipated. This shakedown period must be factored in as a normal penalty if the full potential of automation is to be realized.

R. McMichael: There is one thing that is rather obvious in this situation; in taking operators that have been used to dealing with 3-high mills and putting them on to a mill such as this considerable difficulty would be encountered in attaining maximum production. It would be interesting to know the method used in training the personnel and the procedures that were followed in the training of these people.

R. R. Fayles: In this installation you apparently tripled your output. I wonder what you did with the number of people involved when you had such a great increase in automation, people both in operating and in maintenance.

I noticed that the picture of the shears showed a one-man operation. I did not see anyone on the ground, and I wondered if you had any problem in tolerance in shearing with this type of operation.

F. W. Wagner: To answer Mr. McMichael's question in breaking in crews for the new 4-high, 160-in. reversing plate mill, we encountered very little trouble.

The drafting that a roller did on a 3-high mill was less severe than what we would expect to do on a 4-high mill so it was only a case of starting with what we knew, and increasing our drafts as we went along.

The manipulator on the 4-high mill posed no problems as a table operator on a 3-high mill had just as many controls to operate, and, while rolling plates of shorter lengths, had to operate the controls much faster.

In breaking in crews for the shears on the finishing end, we were confronted with a different problem.

On our old shearing equipment, it was mainly "bull" work that did the job. We had our doubts whether this type of employee could operate the highly mechanized equipment of the new finishing end.

We decided to give these employees the opportunity to operate these shears.

We selected the better employees and broke in one crew at a time, allowing one week's training per crew.

It was discouraging at times as the skill acquired during a week's operation seemed to vanish over the weekend, so we had to start all over with a refresher course at the start of a new week.

It was not a lack of effort of co-operation on the part of these employees. It was something totally different from what they had ever done before.

We were confronted with some mechanical problems, so it was not altogether the fault of the operators that production did not come up to expectations at first.

With most of the mechanical difficulties and training problems behind us, we are now ready to produce. Our present average of 190 to 200 slabs per turn is prooof that we have come a long way since March, 1957.

To answer Mr. Fayles' question, in the operating end, we have realized approximately 50 per cent of the savings in manpower that was anticipated. Due to our low tons per hour, it was necessary to operate 20 turns per week instead of the 15 or 16 turns weekly as originally planned. However, as our tons per turn increase, we should be able to decrease the number of rolling and finishing turns needed.

The mechanical and electrical forces did not decrease. With more complicated equipment and complex controls, the maintenance problem was greater, hence additions had to be made to these forces.

C. W. Ritterhoff: Our major problems on the shears can be divided into two categories; those on the side shear line which cuts plates from $\frac{3}{16}$ in. to $1\frac{1}{2}$ in. thick, and the others on the rotary shear line which cuts plates from $\frac{3}{16}$ in. to $\frac{1}{2}$ in. thick.

The side shears have a scrap cutoff knife at right angles to the main knife which cuts the scrap free of the plate with each cut. When we started to use these shears, we experienced a great deal of trouble with notches or indentation between the cuts along the side of the plates. This caused us to reshear or reline an excessive number of plates and we were unable to load plates directly from our roller line. At first, we considered the possibility of removing the cutoff knife and using the scrap as a guide for succeeding cuts. This would have made the handling of scrap very difficult at our scrap shears so we decided to keep this feature. We finally devised a straight edge in line with the knives and installed a mechanical pusher to position the plate. Now, after each cut, the plate is advanced and positioned against the straight edge before the next cut is made. This method of realining the plate has eliminated our notch problems.

We have no trouble at all meeting commercial tolerance on the side shear line. We have some difficulties on resquare work because this requires a great deal of operator skill which has not been fully developed.

Our rotary trimmer gave us quite a lot of trouble at the beginning. It was a new piece of equipment and we had to learn the proper knife settings. Now we are having very good success with the trimmer, and we have cut approximately 1000 tons of $\frac{1}{2}$-in. plate in eight hours. This machine does a good job cutting plates to $\frac{1}{16}$-in. parallel along the width. The shear on the end cuts the length so that we can keep the diagonals on a 200-in. plate within a quarter of an inch.

The shear crew consists of two men, the shearman and the scrap tender. The shearman positions the plate and makes the cut. The scrap is carried on a conveyor from beneath the knife and is cut by alligator shears which are operated by the scrap tender. When we cut heavy gage work, over $1\frac{1}{4}$ in. it is usually necessary to have two scrap tenders to keep the scrap feeding into the alligator shears.

H. R. Knust: We would like to emphasize again the wonderful cooperation and coordination that existed between the operating and the construction dept. on this job, as well as that which existed between the mechanical, electrical and engineering dept.

We are very proud of this mill. We have had some operating and maintenance problems. However, we are ready to turn the mill loose and feel confident that we will, in the near future, have a 70,000 ton or better month. ▲

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Provo, Utah

. . . . conservation and economic utilization of raw materials have become increasingly important in the steel industry and water is no less important than coal or iron ore . . . .

ONE of the basic concepts within the steel industry is that of conservation and proper utilization of all raw materials and equipment. The necessity of this policy is well illustrated by the ever increasing consumer demand to produce steel and steel products as cheaply as possible. Along with iron ore, coal, limestone and scrap, it is certainly appropriate to list water as one of the important raw materials in the steelmaking process. For example, at the Geneva plant it takes approximately 40,000 gal of washing, cleaning and cooling water to produce one ton of finished product.

Since the Geneva plant was built rather late in the development of Utah county as far as water is concerned, it was necessary to draw from many and varied sources of supply. These sources consist of deep and shallow wells, irrigation ditches, springs, subsurface drains, the Provo River, and the Deer Creek Reservoir in Provo Canyon.

However, even with all these available sources, the average quantity of water entering the Geneva plant fulfills approximately only one tenth of the total plant requirements. Also, a great portion of the water entering the collection systems cannot be consumptively used without infringing upon the rights of downstream water users. Therefore, extensive measurements are continuously made of all flows entering and leaving the plant. At the end of each water year a balance is made of the consumptive and nonconsumptive water. The balance involves calculation of water quantities based on legal titles and previous agricultural usage. These titles are similar to deeds of property, granted by the State of Utah, and are restrictive as to the allowable diverted volume and consumptive loss of water. With this tremendous use of water it is interesting to note Table I showing water entering the plant, water discharged from the plant and the percentage relationship. These balances demonstrate an interesting fact, which is: an industry requiring large amounts of water has been established in a part of the semi-arid west without depleting or interfering with the water rights of other consumers. To illustrate this point a portion of the U. S. Geological Survey Professional Paper 257-A entitled, "The Geology of Northern Utah Valley"[1] reads as follows:

"It must be concluded, therefore, that the Geneva Steel Co., even with its enormous use of water, does not deplete the net available supplies as much as did the same property under an agricultural economy."

It is self-evident that in order to accomplish these objectives and yet operate with a limited supply of

TABLE I
Geneva Water Balance

Water year	Measured water discharged from Geneva, gpm	Measured and estimated water entering Geneva, gpm	Per cent measured supply returned, gpm
1944	12,415	14,370	86.40
1945	12,850	14,089	91.21
1946	10,064	13,269	75.84
1947	13,887	17,630	78.77
1948	15,805	18,640	84.79
1949	16,333	18,983	86.04
1950	16,289	19,410	83.92
1951	17,986	20,939	85.90
1952	20,850	24,025	86.78
1953	21,660	25,241	85.81
1954	21,059	25,082	83.96
1955	17,741	21,143	83.91
1956	14,860	18,450	80.54
1957	16,072	20,225	79.47
1958	15,738	19,266	81.69
Average	16,241	19,584	82.93

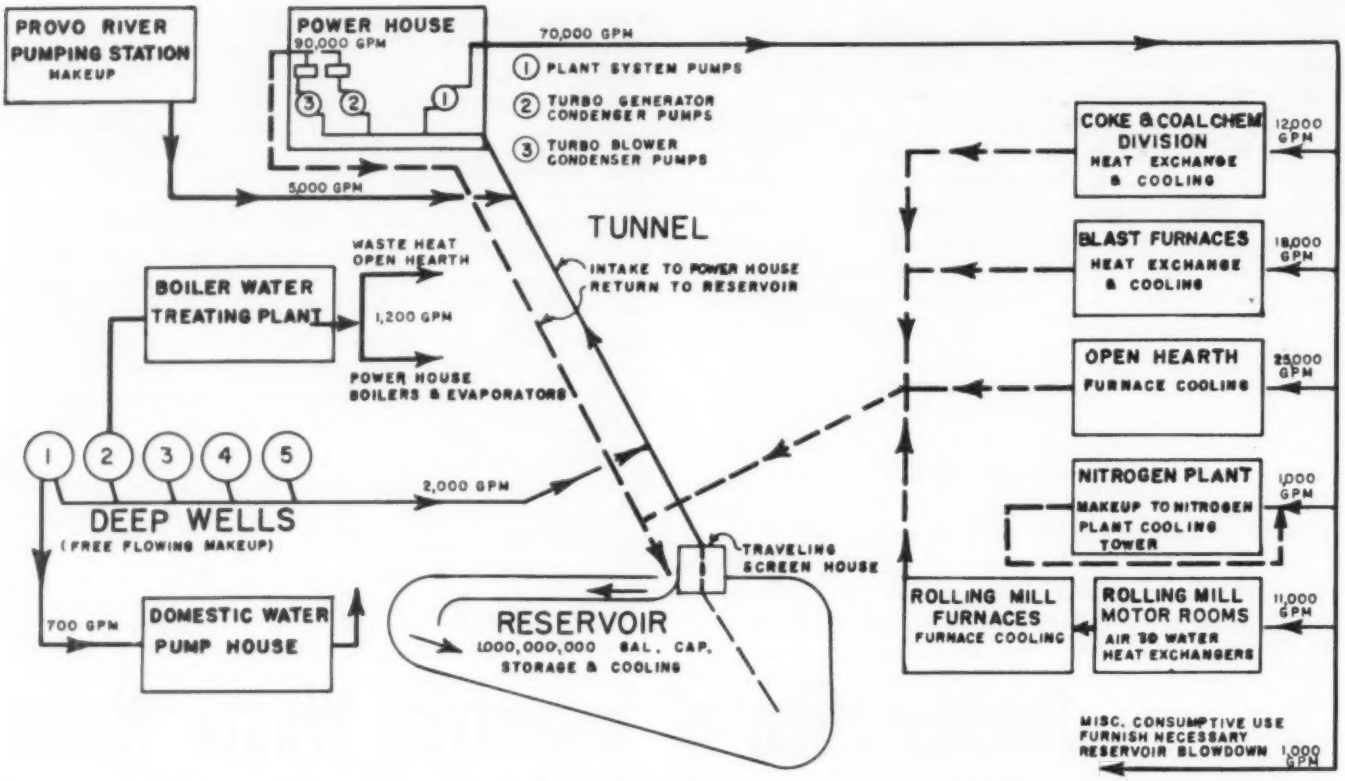


Figure 1 — General arrangement shows the multiplicity of water systems required to furnish the properly treated waters for different uses.

water, an economy program consisting of reclamation and recirculation was necessary.

To describe best the water utilization at Geneva Works, it is well to illustrate the many and various plant water systems. In a sense there are four separate and distinct distribution systems conveying different types of water throughout the plant. These systems are designated as follows: domestic, boiler, treated and untreated water. In the original plant design the water supplies were adapted as to their most advantageous use, particularly with respect to quality. A brief description, together with particular points of interest concerning each distribution system follows.

DOMESTIC WATER SYSTEM

The domestic water supply, illustrated in general flow diagram, Figure 1, is derived from one of the plant's five deep wells. This well has an 18-in. diameter casing and is approximately 1200 ft deep, artesian in nature, and capable of a free flow of 2000 gpm. The water is first chlorinated, stored and then pumped into the plant's distribution system. The average domestic water demand amounts to a flow averaging 650 gpm.

A separate sanitary collection system conducts the domestic waste waters to a complete sewage treatment plant. This waste treatment process consists of grit removal, primary clarification, high rate trickling filtration, secondary settling and chlorination of the final effluent water. The settled organic material is scraped into a separate sludge digestion chamber where it is rendered into a nonoffensive material to be drawn off at various periods onto the sand drying beds. The normal flow of waste water through this treatment process is approximately 270 gpm. After final treatment this water is of such good quality that it is recirculated back into the plant's untreated water supply to be used for industrial washing and flushing.

It will be noted there is a differential of nearly 400 gpm between the domestic water demand and the sewage effluent. This discrepancy is due to the requirement of high quality water at various points and obtainable only from the domestic system.

BOILER FEED WATER SYSTEM

The Geneva boiler feed water system, also shown in Figure 1, derives its source of water from one of the plant's five 1100 to 1200-ft deep wells. This water has a hardness of approximately 110 ppm which in this area is considered quite soft. The water is pumped at a rate of approximately 1200 gpm into a water treating plant, Figure 2, in order to reduce the final water hardness to one ppm. The method of water treating consists of a conventional cold-lime soda-ash process followed by zeolite softening. Originally the softening chemicals were purchased in carload amounts and pneumatically elevated into overhead storage bins. The chemicals were then fed by solution feeders into the solid contact basins where the hardness was reduced by coagulation and sedimentation. Purchase of dry lime has now been replaced with that of waste lime collected at the acetylene plant. The residue produced from generating acetylene from carbide is a high quality calcium hydroxide. This waste product is pumped to the water treating plant, into a continuous slurry mixing tank and fed as a solution to the coagulation basins. This arrangement has worked very satisfactorily and has provided a substantial savings in the operation of the water treatment plant.

Even with skillful operation, the lime soda process, because of a slight solubility, cannot completely reduce the water hardness to zero. In order to accomplish this, the use of soda ash was discontinued and zeolite softening added as an additional refinement.

TREATED WATER SYSTEM

A steel plant needs vast quantities of water for steam condensing, furnace cooling and heat exchange. A 1,000,000,000-gal reservoir using Provo River and deep well water as makeup was constructed for these uses.

This reservoir, shown in Figure 3, serves as a cooling pond as well as a storage basin. The area of the Geneva reservoir covers approximately 312 acres and has a depth varying between 5 and 23 ft. A 9-ft diameter pipeline collects this water at the deepest end and conducts it into the powerhouse where it is then pumped into the plant treated water distribution system. Following its usage within the various parts of the plant, the treated water flows to the reservoir to be cooled and reused. The plant average treated water demand is approximately 160,000 gpm or 357 sec ft. Of this total amount, 90,000 gpm is used in the condensing of steam within the powerhouse. The remaining amount of 70,000 gpm is used in the coke plant, blast furnace, open hearth and rolling mill areas.

The distribution of these flows is illustrated in Figure 1. As previously stated, this entire quantity except a few minor losses is returned to the reservoir for cooling by evaporation. A differential of 10 F is obtained between the inlet and the outlet of the reservoir. This cooling effect, considering the large amount of water being handled, is approximately 800,000,000 Btu per hr. Comparing this heat loss to the rating of a typical home furnace, it means that enough heat for a city of 24,000 people is being continually dissipated in order to cool the circulated treated water. Of course, the outlet reservoir temperature of the cooling water fluctuates seasonally. During the winter, it will drop to a low of 50 F and increase to a high of 85 F in the summer months.

Due to the high temperature and the quality of the recirculated water, it is necessary to add various chemicals in order to control formation of scale within the plant heat exchangers. When scale coats the inside of a metal surface transferring heat to water, an insulating blanket is formed and the outside metal temperature increases. If this outside temperature is high enough and the insulating effect great enough, the metal surface becomes overheated and erodes away. The severity of this problem becomes enormous when, for instance, a cooler protecting a beam, which in turn supports an open hearth furnace roof, fails and steel production for that unit is stopped.

To prevent calcium carbonate deposition, a glassy phosphate is added to the circulating water at a rate of two ppm. This glassy phosphate is a surface active agent that prevents deposition by preventing crystal growth. In effect, surface active agents broaden or increase the solubility of the scale forming salts and permit an over-saturated condition to exist without precipitation from solution. This method of treatment is also quite effective in minimizing corrosion attack in the cooler parts of the system.

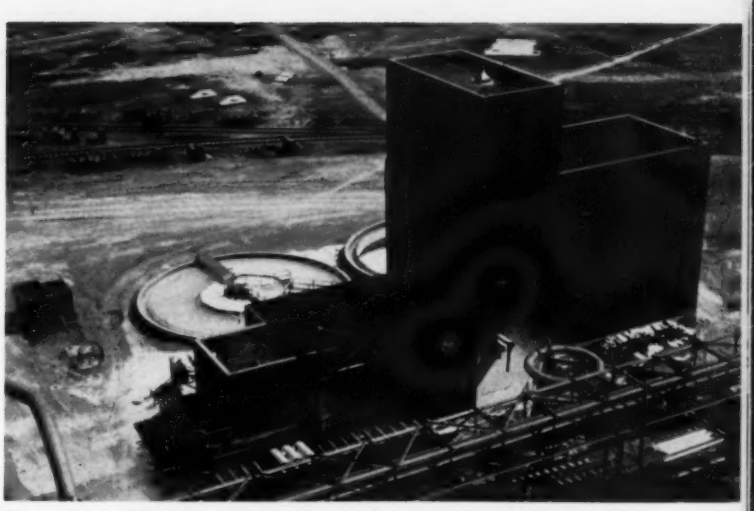


Figure 2 — Boiler feed water is reduced to a hardness of 1 ppm in Geneva Works water treatment plant.

The effectiveness of the glassy phosphate treatment is also inversely proportional to the pH of the water. In order to control pH, a sulphuric acid feeding system with automatic control is in continuous operation.

With this equipment, the general plant treated water supply is maintained at a pH of 8 or less and the open hearth supply is reduced to a pH of 6.5. It is necessary to feed between 700 and 3500 gal of sulphuric acid per day.

For a number of years the most interesting phenomenon in connection with this system has been the erratic and unpredictable change in pH of the reservoir water. The treated water returns to the reservoir from the plant at a pH of 8 or less. By the time it circulates through the reservoir, it will increase in pH to as high as 9.2. The reason for this increase is that the microscopic plankton and algae growths within the reservoir are capable of removing the free carbon dioxide and the bound carbon dioxide in the water bicarbonates, and utilize this compound in photosynthesis. This results in raising the alkalinity and pH of the water. Due to these minute plants and organisms, it is necessary to add as high as 3500 gal of sulphuric acid per day. Treating the reservoir intermittently with chlorine and copper sulphate has been attempted as a control meas-

Figure 3 — A 1,000,000,000-gal capacity reservoir is used to both cool and hold water for operations at Geneva Works.

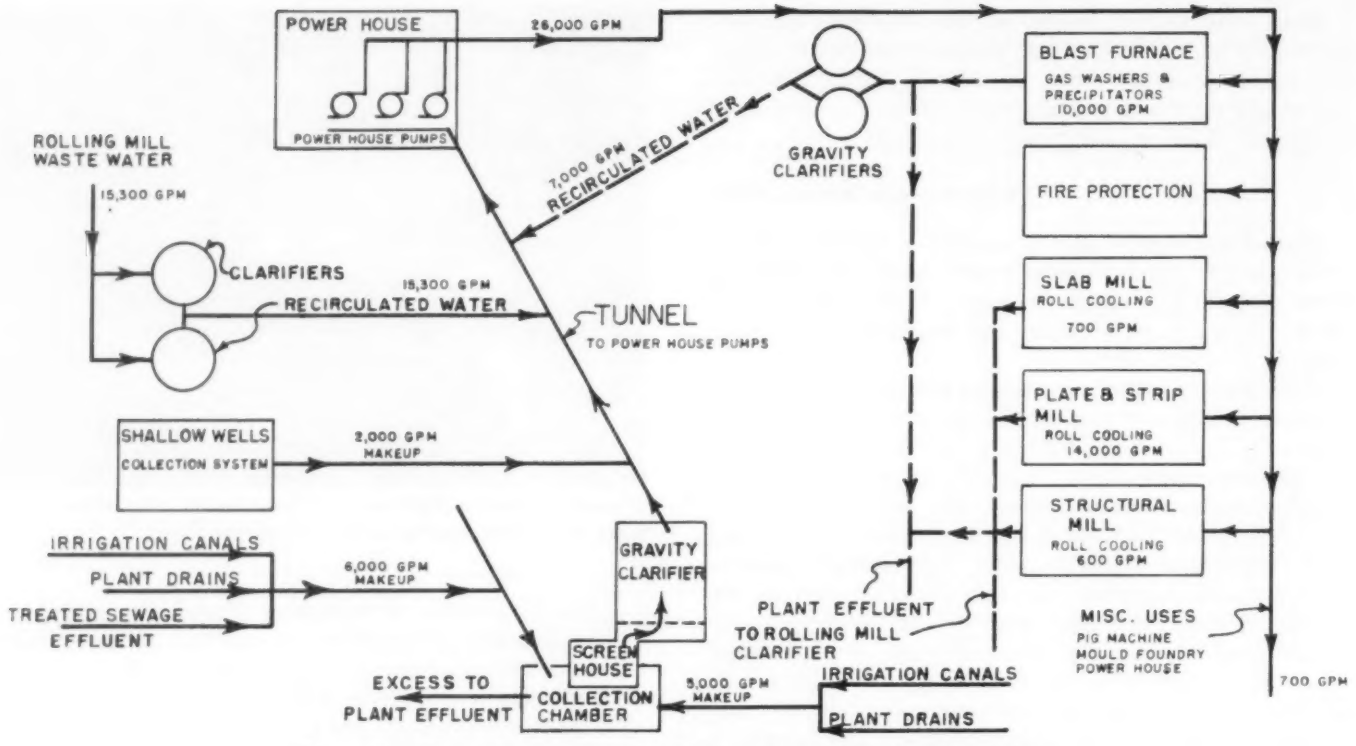


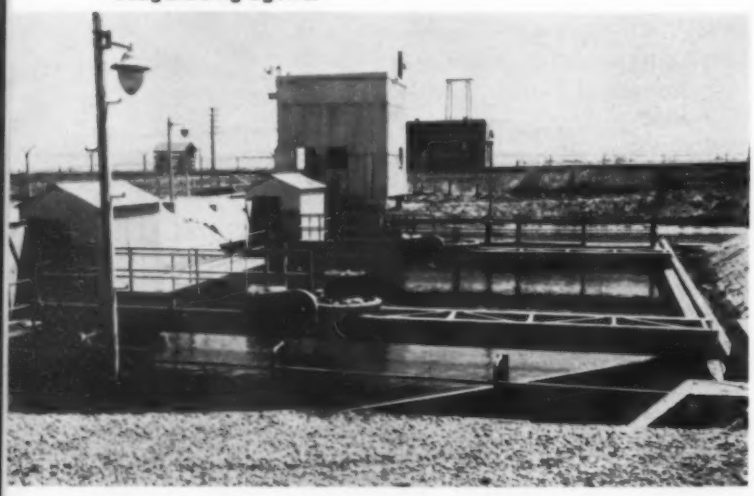
Figure 4 — General arrangement of Geneva's untreated water system.

ure. This treatment is successful, but due to the high water temperatures, large surface areas and food available in the form of phosphate, the growths multiply again in a very short period. This is a problem which is constantly under investigation. To date no simple and economical solution has been found.

UNTREATED WATER SYSTEM

The plant further needs water for descaling, roll cooling and the cleaning of blast furnace gas. Quality with respect to scale and corrosion is not as critical for these uses as with the cooling and condensing water. The Geneva Plant utilizes shallow wells, irrigation and drainage water for this service without the application of chemicals. For this reason, the supply is designated as the untreated water system. Figure 4 illustrates the general flow pattern and water requirements of this system. The surface water as it enters the plant contains a considerable quantity of sand, silt and floating debris. Therefore, it is necessary to conduct the entering flow through plain settling basins, Figure 5, before it is pumped to the various plant consumers. The average demand of this system is approximately 26,000 gpm. In order to meet this requirement, it is also necessary to clarify and recirculate various waste waters.

Figure 5 — Settling basins are used to clarify untreated water requirements, using aluminum sulphate as a coagulating agent.



BLAST FURNACE WASTE WATER RECLAMATION

The Geneva Plant has three blast furnaces along with auxiliary furnace equipment. The blast furnace gas produced by each unit flows through a dry-dust catcher and into a wet gas washer. Within this washer water is sprayed down through a series of hurdles countercurrent to the dust laden gas. The total volume of wash water used for this purpose is approximately 10,000 gpm or 34 gal per thousand std cu ft of gas. This waste water is then conducted to a wet well, where it is pumped into two clarifiers shown in Figure 6. Each of these clarifiers is 110 ft in diameter with an average water depth of 10 ft. The detention period calculated on a fill and draw basis is approximately two hr. Tests conducted on the efficiency of these units indicate an average influent loading of approximately 660 ppm suspended solids and an average effluent of 64 ppm. The efficiency of these clarifiers is, therefore, approximately 90 per cent. Since a large portion of these solids is iron, the sludge is of considerable value. The wet sludge is pumped to open drying beds, and later utilized at the sintering plant.

The major portion of the clarified effluent water is recirculated back into the plant untreated water system.

ROLLING MILL WASTE WATER RECLAMATION

The second major users of untreated water are the

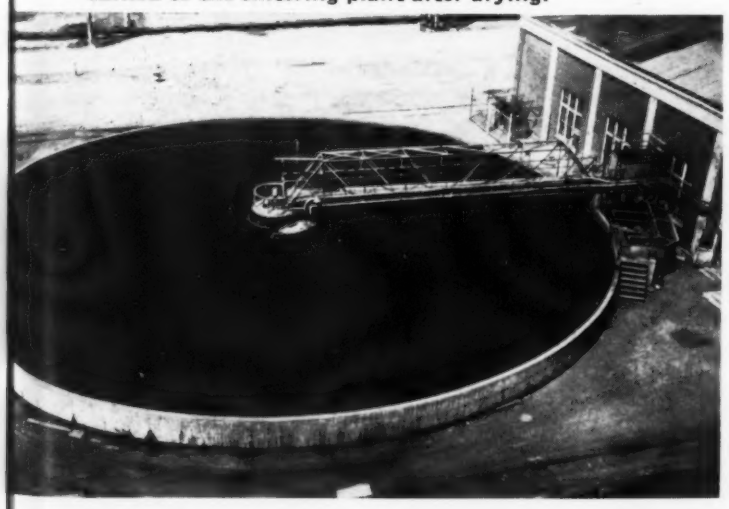
cooling and descaling facilities within the rolling mill area. The water requirement of this portion of the plant is approximately 15,000 gpm. In the past, a small portion of this flow was recirculated with only partial treatment. However, difficulties were encountered because the waste water contained oil and fine particles of mill scale. These contaminants clogged screens and caused considerable abrasion of sprays and pumps. As a means of alleviating this condition, plus providing additional water for future expansion of plant facilities, approval was recently granted for construction of clarification facilities to treat the rolling mill waste water. This treatment plant, Figure 7, consists of a pumping station, chemical feeding equipment, flocculation, sedimentation and oil separation facilities. The effluent water is reclaimed and piped back to the untreated water system. Although the present flow is only 15,000 gpm, this treatment plant has been designed to handle an ultimate flow of 20,000 gpm.

The pumping station for this waste treatment plant consists of a concrete wet well 24 ft wide × 43 ft long × 13 ft-6 in. deep, having a maximum storage of 105,000 gal, and a design detention period of five min. Three 10,000-gpm pumps are available with one pump to be used for standby service. Float switches start, stop and alternate these pumps at the various water elevations within the wet well. Since the scale-laden water is very abrasive, the pump impellers are composed of ni-hard material.

The combined flow of the pumped water is then discharged through a flow tube metering element before being equally divided into the settling basins. The metering equipment measures and records the volume of water pumped, and activates the chemical feeders proportionally to the rate of flow.

The settling velocities of the scale particles are extremely small and the design of a clarifying tank using natural settling conditions would have required a very long detention period. In order to shorten this settling period, aluminum sulphate is added to the waste water as a coagulating agent. By adding this chemical, a gelatinous or flocculent precipitate is formed which entangles the suspended particles. The heavy floc particles settle rapidly and in their downward path become larger and more dense. Laboratory jar tests have indicated that optimum results are obtained when 15 ppm of aluminum sulphate are added to the waste water. At the plant design flow of 20,000 gpm, the chemical requirement will consist of 3600 lb of coagulant per day.

Figure 6 — Water from the blast furnace gas washer is clarified to remove iron containing sludge which is returned to the sintering plant after drying.



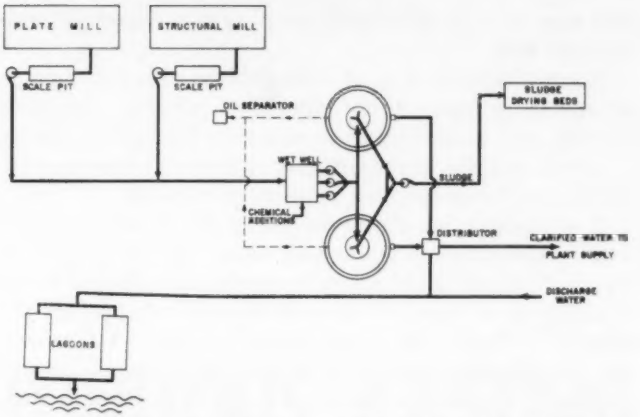


Figure 7 — Rolling mill waste water plant is designed to handle 20,000 gpm.

The settling basins consist of two circular concrete tanks, 135 ft in diameter and having a side water depth of 14 ft. Within the center of each tank is a reaction compartment having a 30-min detention period. It is at this point that the floc particles are developed in order to accelerate the settling velocity of the mill scale. This is accomplished by a flash recirculation propeller and slow moving vertical mixing paddles.

Design features of the sedimentation compartment of the tank consists of a detention period of two hr, a surface settling rate of 1000 gal per day per sq ft of tank area, and a weir loading of 10,000 gal per day per lineal feet. This low weir loading is obtained by the installation of auxiliary launder troughs approximately 7 ft from the side of the tank wall. A scraping mechanism at the bottom of the tank collects the settled sludge and rakes it to a central hopper compartment. This sludge is then pumped to open drying beds where it is reclaimed for sintering use.

Grease and free oil are removed from the waste water by automatic skimming blades attached to the sludge rakes. The skimming mechanism scrapes the floating surface material into a collection box attached to the overflow weirs. The oil is then piped to an oil separation unit capable of concentrating and storing the material.

The clarified effluent water from this new waste treatment plant is piped back to the Geneva untreated water system for reuse, or it may be discharged to waste if sufficient natural water is available.

This treatment plant is capable of clarifying the rolling mill waste water by reducing the suspended solids content of 150 ppm to less than 15 ppm, and the oil content of 70 ppm to less than 5 ppm. This provides an excellent quality of water suitable for many uses throughout the plant.

SUMMARY

Geneva Works has entered the field of industrial waste treatment as a means of improving product quality and conserving its limited water resources. The available quantity of supply water fluctuates seasonally

and may not be depended upon as a constant or continuous flow.

A large industrial plant such as Geneva is not capable of operating under these conditions without extensive storage and recirculating equipment. The plant cooling reservoir and the new clarifying equipment now provide the means to accomplish these requirements.

A secondary benefit to this program of water control and recirculation is the improvement in the quality of water discharged. In many respects this effluent water is superior to that of the surface waters entering the plant. Normally, the local irrigation and ditch waters are very turbid and contain high quantities of organic material. With the clarification facilities described above the plant is actually improving discharge water quality rather than impairing it.

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Discussion

PRESENTED BY

W. C. BENNETT, District Manager, Hagan Chemicals & Controls, Inc., Denver, Colo.

W. C. Bennett: The water systems described by the authors have developed during the many years of operations of the Geneva Works. Each individual system has been altered periodically to meet new operating problems. System details will change in the future, for the Geneva Works is a living industrial entity whose design and demands are forever changing.

The authors have well described the system designs and the physical tools currently available for control of water flow and quality. They have outlined the most prominent of the basic treatment methods now employed. The day by day maintenance of proper treatment methods is essential to this reclamation problem.

In this semi-arid area, the dependable availability of the water supply is frequently a major problem. Well water has been a primary supply at the Geneva Works. Initial well operations revealed serious and continuing drops in well production. Orthodox mechanical and chemical cleaning methods, including acid and carbon dioxide, were used without success. Further investigation indicated significant bacterial growths were contributing to flow restriction. Custom cleaning methods utilizing both sterilizing and dispersive reagents were successfully developed and applied. An intermittent cleaning program has now firmly proved the availability of this basic well supply.

The authors emphasize the necessity of maximum reuse of available water supplies. When reused, however, it is literally true that "Water Always Causes Trouble."

Problems of clarification must be solved when water picks up suspended solids from washing and cleaning operations. Optimum clarification is frequently difficult with use of basic coagulants such as alum, even when the most modern type of clarifying equipment are available. The water treatment industry has recently made significant advances in the art of process coagulation. New coagulant aids have been developed which frequently improve both the efficiency and economics of the operation. These new materials are under study at the Geneva Works, and may prove to be essential tools in the operation of the rolling mill and blast furnace clarifiers.

Corrosion is a constant enemy which frequently intensifies its attack when water is reused. An example is the return condensate system for the Geneva low pressure steam system. Severe corrosive properties of the condensate led to early failure and abandonment of the return system. Efficient and practical condensate treatment methods were not then available. New filming amine treatment now provides excellent protection against this type of attack, and has proved effective in other boiler circuits at the Geneva Works. Reuse of condensate is another potential step in the continuing reclamation program.

The Geneva Works does not depend upon cooling tower systems as much as many other major industries in the West. A new cooling tower system at the Geneva Works, however, is complicated by process requirements for aluminum heat exchangers. Copper contamination of the makeup and the circulating waters can promote serious copper corrosion of aluminum tubes. A new filming type organic corrosion inhibitor specific for copper is used to combat this type of attack. At the same time, new organic biocides are used to sterilize the system and to keep the exchanger tubes free of debris which could promote corrosion. ▲

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by H. B. OSBORN, JR., Technical Director
Tocco Div., The Ohio Crankshaft Corp., Cleveland, Ohio

CONTINUOUS CASTING

A smooth clean surface, consistent structure, control and a reduction of overall processing costs are a few of the benefits of continuous casting.

DURING the past several hundred years, many marked changes have taken place in the melting and casting techniques used in the making of iron and steel. These include the substitution of coke for charcoal, use of preheating with the heat generated by smelting, replacing sand with ingot molds, the bessemer converter, the open hearth, the arc furnace and the induction furnace. Until recently, however, the primitive method of casting into forms has seen little basic change—either in the ferrous or the nonferrous field. Steel for example is poured into molds, a substantial portion scrapped, reheated and ultimately shaped into intermediate or semi-finished products.

Anyone familiar with the general practices of the metalmaking industry must for years have been intrigued with the idea of being able to cast molten metal continuously into a finished or semi-finished shape. The obvious elimination of equipment and labor have challenged the imagination for many years. Bessemer himself (1858) succeeded in casting several flat slabs of malleable iron between rotating chilled rolls.

The lower casting temperatures of the nonferrous materials made them the object of an early concentrated effort to achieve results. Thus for the past 15 years continuous casting of such things as 1 in. copper rod or 6 × 24-in. aluminum slabs have been routine industrial practice. More recently the continuous casting of steel has become a reality.

ADVANTAGES

Any product, even a bar of steel, must be pleasing to the eye if it is to sell competitively. Conventionally cast ingots have much to be desired. The amount of money spent in surface preparation for subsequent operations is staggering—all pits and blow holes must be removed. A properly continuously cast bar need have none of these.

A standard ingot mold with all its fancy "hot tops" still produces a crater, and shrinking, as the metal freezes, cannot be eliminated nor is it possible to completely prevent segregation. Further good and consistent control of structure is practically beyond reasonable expectation. Continuous casting can solve all of these problems.

Nowhere in the analysis of the economies of the continuous casting of nonferrous metals can there be found the potentials available in the application of such a process to steel. It removes from the conventional process of steelmaking what constitutes the most expensive part of a mill—equipment for handling ingots, soaking pits and blooming mills. The cost of such equipment has resulted in a highly centralized steel industry. The use of continuous casting on the other hand permits decentralization and low capital and operational cost.

With a continuous casting process, small populated areas could support their own mill, and f.o.b. mill prices would have some reasonable significance contrasted to the varied prices resulting from the large discrepancies in delivery rates throughout the United States. At the outset it may appear that the advantages can only be worthwhile on high cost steel. However, the economies are such that equipment for casting 1 in. round carbon steel bars can be justified.

This paper limits consideration to the ferrous field and tabulates for ready reference the advantages of a successful process for the continuous casting of the liquid metal which can be produced economically and with a minimum of labor.

1. Eliminate the cost of surface conditioning.
2. Eliminate segregation.
3. Eliminate craters responsible for high scrap loss which averages 25 to 30 per cent.
4. Eliminate soaking pits and blooming mills.
5. Completely automatic.

All of the above result in substantial savings in labor and equipment or both.

HISTORICAL

The first real evidence of more than just interest in this process is found in a patent issued in 1843 to J. H. Laing. It described a machine and a method of continuously casting tubing using a vibrating mandrel. Although no equipment was ever built according to such specifications, it would appear to be the granddaddy of all that followed.

H. Bessemer demonstrated the practicability of the idea in 1858 when he poured metal between rotating chilled rolls and produced a sizable slab almost four ft. long. This slab is today a museum piece which has stood as a challenge these many years with its smooth clean surface and good metallurgical structure.

Since that time there have been many men, dollars and patents concerned with the continuous casting of steel, but only within the past several years have the results been significant enough to warrant the assignment of a success label.

BASIC FEATURES

Continuous casting is just what the name implies. The hot metal is poured from a ladle into a funnel-shaped object called a tundish from whence it flows into a water-cooled mold, and then onto the top of a starting bar inserted therein. The bar is then withdrawn slowly. As the metal passes through the mold the surface chills until it can retain its shape and its liquid center. It then emerges from the mold into a set of rolls as it continues to be cooled and solidified throughout. Finally it is cut to length.

Preparing liquid metal for pouring and handling hot bars presents no problem. The secret of success and wherein the problems arise is in handling the metal from the time it pours from the ladle and until it leaves the mold.

The tundish provides a means for controlling the rate of flow by regulating the level in it. Also here is where provisions must be made for holding back slag since if any goes through into the mold it eventually will cause sticking.

The mold is the heart of this process. The material used for its construction must have high heat conductivity so that the water cooling within it will be sufficient to properly "freeze" the metal going through it. Several metals can be used, but copper or brass are preferred, depending upon strength required. Further, somehow its inside face should be able to maintain a nonwetting relationship with the liquid metal. The surface has to be smooth and stay that way during the casting process so as to prevent seizure and assure a smooth surface on the product.

Lubrication of the mold can be accomplished in various ways—gas from the bottom or liquid from the top. Some methods use neither. Herein lies much of the operating difficulty of machines now in use.

The shape and size of the molds seems to constitute the major difference between the various machines which have been built over the years. Any reference to such machines in this article will point this out.

The quicker the liquid metal can be frozen and run out of the mold the better will be the results. The surface will be smoother and the solidification through the cross section less subject to disturbance. Just keeping water on one side of the mold will not provide adequate cooling. The coolant must keep circulating through the mold fast enough to remove the heat as it is absorbed by the mold. The design of the water passages must not permit any "dead" areas. Thus to maintain a minimum of surface area (so the metal is not in contact too long) and at the same time cool rapidly enough, a tremendous amount of heat has to be removed so as to protect the mold. It is desirable to use enough water (several hundred gpm in some cases) so as to get only a few degrees temperature rise.

Just as soon as a shell forms in the mold and the liquid within starts cooling, there is a contraction and the billet shrinks away from the mold walls. The gap produced makes it still more difficult to do effective cooling of the billet. It is at this point when the billet must acquire enough strength to stay together.

Since the control of heat removal is vital to the success of continuous casting, the temperature at which the metal reaches the mold is also important so as to maintain uniform operating conditions. Additionally, the temperature at which the liquid has the proper viscosity characteristics is critical and varies with analysis. The production operation of the several machines now in use depends to a large measure on how well this temperature has been controlled.

All of the variables attendant to the successful operation of a continuous casting machine are far too numerous to cover here but include careful control of:

1. Pouring temperature.
2. Pouring rate.
3. Cooling rate in mold.
4. Rate of withdrawal from mold.
5. Cooling rate after leaving mold.

RECENT INSTALLATIONS

Babcock & Wilcox—Early in 1942 Republic Steel started a development program applying the ideas of E. R. Williams (Vulcan Mold & Iron Co). Later on in 1944 the work was transferred to Babcock & Wilcox at Barberton where a small unit was built. Then, based on what had been learned, a full sized installation was begun at the Beaver Falls plant. However, it was not until early in 1948 that a production run was obtained—some 50 tons of SAE 1015 as 6-in. rounds. The mold of this equipment is basically a water-cooled tube, round or oval in shape, and many feet long, capable of handling 45 sq. in. of cross section at a rate of approximately 500 lb per min. It is claimed no lubricant is used to avoid porous areas and to prevent build up which causes sticking. The wavy appearance of the inside of this mold after usage, and operating diffi-

culties of various sorts seem to indicate that the process is not completely acceptable.

Allegheny Ludlum—As early as 1930 Allegheny Ludlum dabbled in continuous casting in their Brackenridge plant. Plagued with difficulties innumerable, the machine built was abandoned. But in 1949 they tried again. This time at their Watervliet plant with a Rossi-Junghans machine almost identical to the many units used for years on brass.

The prime interest was in alloy steel because of the greater savings with the higher cost material. Some four years went by before they were able to cast a variety of alloy steels of good quality.

The mold is of the oscillating type which travels downward with the casting for approximately ¾ in. and then returns to its initial position. It is heavy and rigid and varies in length from 2 to 3 ft. Results were sufficiently successful to bring about the organization of a company owned jointly by Allegheny Ludlum and several other interested participating companies.

Atlas Steels—In 1953 Atlas Steels Ltd. decided to make the first big step to be undertaken by any steel company large or small on the North American continent. A full sized setup was planned for their Welland, Ont., plant. It was to produce stock 4¼ x 4¼ in. 5½ x 7½ in. and 5½ x 21½ in. The machine was made possible through the organization referred to above and was planned for 150 tons per 24 hr. After a year in operation results are up to expectations. However, the high cost of the equipment and royalty fees make it somewhat unattractive.

Jacob Holtzer—All the recent activity has not been on this side of the Atlantic. The Jacob Holtzer Works of Compagnie des Ateliers et Forges de la Loire, Unieux, France, are running on a limited production basis. All grades of high-alloy steel are made at a rate of approximately 30 tons per day.

The molds (and thus the billets) are oval in shape and are short (27 in.) copper tubes. The inside face is chrome plated. Pouring is from one or two spouts so they can cast two sections 2 x 3⅛ in. or one 3⅛ x 4⅛ in.

William Jessop & Sons Ltd.—The British too have a plant in semi-production in Sheffield. This plant was designed in consultation with the British Iron & Steel Research Association.

Stock run so far has not exceeded 4 x 4 in. and they use a very short brass or copper spring mounted mold. The billet is pulled from the bottom of the mold at a rate of 5 fpm. The chilled metal sticks to the mold and travels down with it until the spring force pulls it free and the mold returns to its original position. However, sometimes it does not let go and stays "stuck."

The springs were planned originally to measure the forces which develop between the billet and the mold and which are responsible for rupturing of the skin—such ruptures when not healed allowed molten metal to pour out from the center of the billet as it left the bottom of the mold. It is not known whether or not the measurements did them any good but the operational aspect of the spring-mounted mold as described in the paragraph preceding gives them an automatic oscillating mold like the one previously mentioned. Since it "happened" and was not an obvious device to get around the patent, it appears that the British steel industry can get along on its own provided that the technique really is satisfactory for production.

WHY INDUCTION HEATING

Some ten years ago some ideas on continuous casting were proposed which, if they would work, seemed to indicate a technique more reliable and cheaper than anything so far accomplished. Partial success came in several attempts at Empire Steel and Braeburn Steel.

One feature is a three-section segmented mold with sections approximately 18 in. high and with each of slightly larger cross section so as to allow for the dimensional changes which take place in the billet and to provide adequate space for lubricant. The lubricants used varied but the ultimate method was one using a material which filled the gap between the mold wall and billet surface and yet still had good heat transfer properties.

A study was made by the writer of the operating difficulties of all of the installations described in this article as well as those of these units. After a detailed analysis it appeared that a combination of the mold and lubricating ideas with a properly designed inductively heated tundish would answer most, if not all, of these difficulties.

Our company completed the design of a 4 x 18-in. machine but decided to build a 4 x 4-in. unit instead because of the keen (renewed) interest of Braeburn who still had feed rolls, etc., on hand to handle that size. The mold assembly of this unit is 54 in. long and has already been tested for dimensional stability by having cast short test sections. The mold is segmented in four pieces, each of which is of rigid construction, efficiently water cooled and adjustable. Further, when necessary, refacing can be readily accomplished because of the simple design.

The lubricating technique has been tested and the test sections come from the mold completely coated with the material used. Patents are pending on this.

The tundish has two separate induction coils—one for the spouts and the other the main body. A 300-kw, 3000-cycle generator with separate controls for each coil will be used. There are two features of this that are important.

1. The tundish will provide a real temperature control for the metal and assure pouring at a constant temperature. With power on one can add heat and with power off one can cool effectively with the water going through the inductor coils.
2. Further, the magnetic field from the coil around the spouts provides a stabilizing effect on the stream and as strange as it may seem prevents it from splashing—thus it is possible to maintain a "quiet" level in the top of the mold.

SUMMARY

One may well wonder why a steelman's dream of hundreds of years ago has taken so long to become a reality. Though tried many times through the years it was not until 1930 that the nonferrous industry tried it successfully. Some dozen years later the first ferrous bars emerged from a production operation. ▲

Experience in Cleaning Blast Furnace Gas with the Orifice Washer

by G. E. REID,
Utility Engineer
Steam Efficiency and Combustion Dept.
Pittsburgh Works Div.
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

. . . . orifice washers offer low maintenance and relatively simple construction—provide a low dust level blast furnace gas, which means a greater percentage of iron laden dust is available for reclamation. In addition there is reduction of maintenance on gas consuming equipment . . . .

THE Pittsburgh Works Division of Jones & Laughlin Steel Corp. is a large integrated steel plant situated along the banks of the Monongahela river at Pittsburgh, Pa. Basic iron requirements for open hearth steel making use are provided by the operation of six blast furnaces, ranging in capacity from 850 to 1350 tons per day. No ferromanganese is produced by Pittsburgh Works blast furnaces. When all six furnaces are operating, normal generation of blast furnace gas approximates 715,000,000 cu ft per day.

Prior to the development of the orifice type washer, all blast furnace gas was cleaned in conventional tower scrubbers equipped with water sprays and carried an average cleaned gas loading of 0.2 grain per cu ft. Gas destined for stove use received secondary cleaning in its passage through disintegrating scrubbers, but their capacity was limited to the stove requirements of about three furnaces. Stove make-up gas for the remaining furnace stoves was drawn from the primary clean gas main. A small percentage of the total gas flowed to a gas mixing station where, after electrostatic cleaning followed by natural gas addition, the mixed gas was pumped into the coke oven gas main to give controlled stabilization of the coke gas system pressure. However, the major portion of the total blast furnace gas generated under six furnace operation was sent to the boiler plants and burned to make steam. When the gas supply exceeded the gas consuming capacity of the boiler plants, surplus gas was bled to atmosphere by three flared bleeders mounted on the main boiler gas duct.

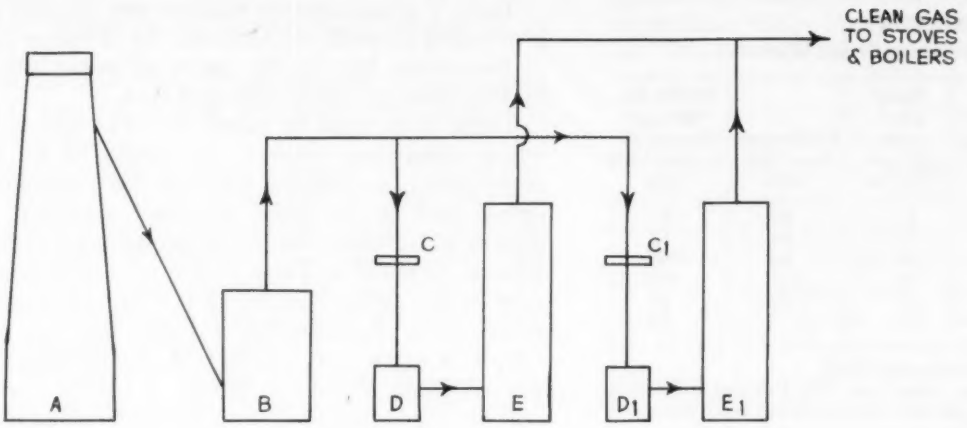
Table I illustrates the distribution of blast furnace gas obtained before the use of the orifice washer. Due to subsequent furnace enlargements, full operation under current conditions has altered this distribution to some extent.

As is indicated in Table I a large daily volume of gas was processed which carried a normal dust loading of 0.2 grain per cu ft. Obviously, any economically adaptable gas cleaning application that could secure an appreciable reduction in this dust loading would prove of advantage in several respects. It was this fact that prompted the orifice washer trial.

The first orifice washer was placed in service on P-6 furnace which is equipped with a twin set of conventional tower scrubbers. An orifice, followed by a water separation tank, was installed in the vertical gas duct on the inlet side of each of the spray towers. This setup, in effect, embraces two separate orifice installations, one upstream of each tower scrubber, with each handling half the furnace gas generated and finally

TABLE I
Blast Furnace Gas Distribution Six-Furnace Operation

	Millon cu ft per day	Per cent of total
Total generation	660	100
Stove firing and furnace loss	192.5	29.2
Gas mixing station	5.5	0.8
Steam generation	396.0	60.0
Flared bleeder excess	66.0	10.0



A — BLAST FURNACE
B — DUST CATCHER
C-C$_1$ — ORIFICE WASHER
D-D$_1$ — WATER SEPARATION TANK
E-E$_1$ — SPRAY TOWER SCRUBBER

Figure 1 — General arrangement of the P-6 furnace gas circuit shows the flow path using two separate orifice installations and twin tower scrubbers.

flowing from the tower washers into a common clean gas main.

Figure 1 shows a layout of the P-6 furnace gas circuit.

Each orifice, installed in a vertical 4 ft-9 in. diameter gas main, is designed to afford a pressure drop of 30 in. water column for a dry gas flow of 52,000 scfm at flow conditions of 300 F and 41 oz. per sq in. pressure. This pressure loss does not include that contributed by orifice spray water turbulence, which is probably in the vicinity of 8 to 12 in. water column. Spray water is fed into the gas main through sixteen ¾-in. spray pipes spaced equidistantly around the gas main and located 12 in. upstream of the orifice face. The orifice is 2 in. thick with its opening area surfaced with stellite and ground to secure sharp edging.

Table II gives flow data and cleaned gas loading averages obtained from use of this first installation on P-6 furnace.

As may be seen, the clean gas loading of 0.03 grain per cu ft was nearly seven times better than that secured by the conventional method of 0.2 grain per cu ft, a very encouraging performance. Dust tests taken at frequent intervals over a considerable period showed the installation continued to clean the gas to the low level first obtained. The orifice openings did not become obstructed. It was found necessary, however, to give the orifice spray water pipes a periodic cleaning. Aside from this duty, little other maintenance was required.

J. R. Lowe, Pittsburgh Works blast furnace superintendent, published a brief report[1]* on the performance of this first washer installation in 1957. He has been active in promoting the several washer applications at Pittsburgh Works.

Following the successful trial period of P-6 orifice washer, a similar installation was next made on P-3 furnace. A series of tests were taken on the P-3 orifice washer with the resulting data indicating some interesting conclusions.

All clean gas dust loading tests are sampled at the outlet end of the conventional spray tower. Due to a severe water entrainment in the gas, coupled with short duct connections, it is not practical to sample the gas at the outlet side of the orifice washer so as to make a separate determination of its performance. In other words, all clean gas dust loadings reported in this paper represent the combined cleaning performance of both the orifice washer and the spray tower washer.

In order to assess the contribution of each gas washer to the total cleaning effort, tests were first run under normal operating conditions for each washer. These were followed by a test series during which all spray water to the conventional spray tower was valved off, thus giving, for general evaluation purposes, a gas flow cleaned only by the orifice washer. Comparison of the test results for the stated conditions indicates that with an inlet dirty gas loading of 1.82 grains per cu ft, a clean outlet gas loading of 0.014 grains per cu ft was secured with both washers operating normally. This represents an efficiency of 99 per cent. When the spray tower water was shut off, and with an inlet loading of 1.74 grains per cu ft, dust loading in the

* Numbers refer to Bibliography at end of paper.

TABLE II
P-6 Furnace Orifice Washer

Cleaned Gas Loading	
Grains cu ft at standard conditions	0.03
Spray Water Flow	
Gal/1000 cfm	6
Gas Flow Through Each Orifice	
1000 scfm	46

TABLE III
P-3 Orifice Washer Performance Indicating Cleaning Effect of Spray Tower

	No water on tower washer	Normal water on tower washer
Dust Loading, grains per scf		
Orifice washer inlet dirty gas	1.75	1.82
Tower washer outlet (clean gas)	0.034	0.014
Orifice spray water, gal per 1000 scfm	11	9
Tower spray water, gal per 1000 scfm	—	21
Orifice gas flow, 1000 scfm	80	85

TABLE IV
Performance Summary of Orifice Washers

Furnace	Clean gas dust loading grains per scf	Spray water rate gal per 1000 scf	Orifice gas flow 1000 scfm	Orifice design gas flow for 30-in. loss 1000 scfm
P-6*	0.03	6	46	52
P-4	0.01	7	88	73
P-3	0.014	9	85	100
P-2**	0.027	4	112	120
P-1	0.015	8	76	80
P-5	...	...	...	73

* This furnace has two orifices as described.
** Gas sampled in this test came from both P-3 and P-2 orifice washers. Both gas streams then flow into a common spray tower.

clean gas increased to but 0.034 grains per cu ft, giving a 98 per cent cleaning efficiency. Hence, from this comparison it would appear that the spray tower adds little more than 1 per cent to the over-all cleaning function under normal operation. These test results are given as Table III.

Despite the small dust removal action secured from spray tower operation, its continued use has been found necessary to produce an outlet gas sufficiently low in temperature that avoids excessive moisture deposition in the clean gas mains.

As a result of the experience gained on P-6 and on P-3 orifice washer performance, it was decided to equip the four remaining furnaces with this type gas cleaner. This has been done. At current writing, an orifice washer installation is being completed on P-5 furnace, the last of the group of six furnaces to be made.

Although, due to variations in the iron capacities of the six furnaces, considerable differences in furnace gas generation flows do exist, all orifices have been designed to provide a 30-in. water column pressure loss under normal dry gas flow conditions. Each orifice is of the concentric type, is placed in a vertical gas main to permit a downflow of gas through it, and is followed by a water collection tank from which the gas flows into a conventional spray tower.

Use of a segmental orifice, placed in a horizontal run, as is done in most dry blast furnace gas metering applications, may offer some promise. To date, however, since none of our orifice installations has been clogged by material deposit and since all have given such excellently low maintenance performance, no trials in this direction are presently being considered.

Table IV gives a summary of test results taken on all washers available for sampling. Conservatively, it would appear that, by use of the orifice washer, the normal dust loading in cleaned blast furnace gas has been reduced to an average of 0.02 grain per cu ft.

While, as previously stated, the general arrangement of the orifice installation has been fairly well standardized, the method of admitting the spray water upstream of the orifice face has been subjected to considerable experimentation on the six washer installations. Having no posted ground rules by which to abide, it was thought possible that the way by which the flux of spray water is jetted into the gas stream might be of significance in achieving optimum gas cleaning. In other words, one method could be better than others.

Table V illustrates the number and the size of spray pipes used on each installation, the distance upstream of the orifice face to the point of water admittance, and the clean gas dust loading of each.

These data tend to point out that the method of water admission, whether by single or by multiple spray pipes, as well as the distance upstream of the orifice face to the point of water injection, do not appear to be salient factors in producing a cleaned outlet gas. As noted in Table V, the P-5 orifice has but one inlet water spray located 15 ft 7 in. upstream of the orifice face. Because this furnace has not yet been blown in after a recent rebuild, no performance data are available. When the furnace is placed in service, it will be interesting to determine the cleaning effect that this set of conditions will provide.

The findings are somewhat at variance to those advanced by Campbell and Fullerton[2] as a result of their experiences with the orifice washer. It is stated in their paper that an unsatisfactory level of cleaned gas loading obtained when spray water was admitted a distance as close as 12 in. from the orifice face.

Our test results lend support to the theory that the turbulence generated downstream of the orifice about the vena contracta area helps obtain effective dust wetting and so permits the wetted dust removal from the gas stream in the water separation chamber. Sufficient water must be added to the gas stream to secure intimate association by such turbulence for a water capture of dust particles. Just how the water injection upstream of the orifice is accomplished appears not to be a telling factor.

Based on experience acquired thus far in orifice washer installation and operation, some conclusions may be drawn:

1. Elaborate water spray piping arrangements are unnecessary. The important need is the continuous addition of spray water sufficient to wet and ensnare the dust.

2. In a typical gas cleaning circuit, with the gas first being cleaned by the orifice washer and then being scrubbed by the spray tower, practically all dust removal is the result of orifice washer action.

In essence, the scope of the achievement realized by the application of the orifice washer is that it provides a blast furnace gas cleaned to a low dust loading level of 0.02 grain per cu ft. The installation has required little maintenance, is relatively inexpensive to construct and is compatible with existing blast furnace facilities. Due to the added pressure loss offered by the system, however, more power, probably about 3 per cent,

TABLE V
Orifice Washer Water Sprays

Furnace	No. of sprays	Size of sprays, in.	Spray location distance upstream of orifice face, in.	Clean gas dust loading grains per scf
P-6	16	¾	12	0.03
P-4	1	4	24	0.01
P-3	24	¾	12	0.014
P-2	24	¾	12	0.027
P-1	1	4	24	0.015
P-5	1	4	15 ft 7	...

must be developed by the furnace wind blowing prime movers.

The use of blast furnace gas bearing so low a dust level has secured several operating economies not heretofore attainable.

A cleaner gas means that a larger percentage of ore-bearing particles has been withdrawn from the gas stream and sent to the thickeners for reclaim, resulting in an increase in the production of sludge available for sintering. It is estimated that the increase in the recovery of metallics resulting from greater sludge production averages about 3 per cent.

Before the advent of the orifice washer, a 3-in. opening in the checker brick work of furnace stoves was considered the minimum permissible for the then existent gas cleanliness of 0.2 grain per cu ft. Stove checkers are now constructed with a 2¼-in. opening, within the confines of existing stove shells, thus permitting an appreciable gain in thermal efficiency. This condition will allow higher blast temperatures to be carried with a resulting coke saving.

Under six-blast furnace operation, it has been the practice to utilize the steaming capacities of 15 blast furnace gas-fired boilers, ranging in rated steam generation from 10 to 400,000 lb per hr. It had been necessary, under former gas loadings, to clean boiler gas burners three times daily. Furthermore, there were times when the tenacity of the deposition on burner grate bars was such that a hand bar was needed to dislodge it. The low level of dust loading now supplied to the boilers requires burner cleaning but once a day.

Finally, use of the orifice washer has reduced atmospheric pollution. Before its development, gas containing a 0.2 grain per cu ft dust loading was burned in boilers or by flared bleeders openly with impunity because the atmospheric dust discharge was well below existing smoke code tolerances. Under present conditions, with a gas ten times cleaner, it follows that the total weight of dust sent to atmosphere has been reduced in the same ratio. This abatement of atmospheric dust discharge, coupled with other operational gains made possible by this system, have secured an enthusiastic management endorsement on the use of the orifice washer for cleaning blast furnace gas at Pittsburgh Works.

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Discussion

PRESENTED BY

M. J. CONWAY, Millersville, Pa.

G. E. REID, Utility Engineer, Steam Efficiency and Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

T. J. LETTER, General Foreman, Fuel Utilization Dept., South Works, United States Steel Corp., Chicago, Ill.

N. R. KIRKDOFFER, Superintendent, Power, Steam and Combustion Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

W. O. BISHOP, Superintendent, Plant No. 2 Blast Furnaces, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

C. H. GOOD, JR., Chief Engineer, Central Operations, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

M. J. Conway: It is interesting to note that this paper conveys the idea that the cleaning efficiency is not materially influenced by the distance upstream from the orifice that the water is induced. All units which were actually placed in operation, introduced the water 2 feet or less, upstream from the orifice. In the P-5 furnace washer, the point of water injection was 15 ft 7 in. upstream from the orifice, although this unit was never put into operation. What was the purpose of introducing the water so far upstream rather than near the orifice plate as in the other orifice washers?

This paper reports that the orifice plates were designed to develop 30-in. pressure drop calculated on standard gas without water injection. What is the actual measured pressure drop when in operation and scrubbing water is being introduced?

The abstract of this paper printed in the September 14, 1959 issue of the *Iron and Steel Daily News* indicated there would be a discussion of solids build-up ahead of the orifice, and I quote: "Of interest is a tabulation and chart illustrating the actual material build-up within the vertical gas duct upstream of the orifice face and the pressure drops associated with this constriction of duct area."

This subject was not treated in the presentation of Mr. Reid's paper. Can some statement be presented as to the author's experience with build-up ahead of the orifice washer?

G. E. Reid: Mr. Conway's questions are pertinent. Replying to his first one, I can state that the installation was done as an experiment. We are attempting to determine if there is an optimum location for the admission of spray water, or whether its location has any bearing on the gas cleaning result. Of the five orifice installations made prior to this one on P-5 furnace, spray water was admitted 12 in. upstream of the orifice in some and 24 in. in others, as given in the data just discussed. Our test results appeared to indicate no significant difference because of this change. With this in mind it was decided to inject the spray water an appreciable distance from the orifice on the P-5 installation and to assess the effect of this location on the cleaning effort of the system. Unfortunately, this furnace in still undergoing a rebuild so that we have had no opportunity to make tests on the performance of this washer.

On our P-3 furnace orifice washer, manometer readings taken from duct taps located 2½ ft from the orifice face gave a pressure drop of 48 to 50 in. water column under gas flow conditions of 85,000 cfm and with a

spray water rate of 7 gal per 1000 cfm gas flow. This drop, of course, does not represent the permanent pressure loss inflicted by the orifice assembly. The permanent pressure loss is considerably less than that read across the orifice and is, for the Beta ratio used in the orifice design, about 65 per cent of the observed orifice differential or approximately 33 in. water column.

Mr. Conway has correctly stated that an abstract of this paper carried in an issue of the *Iron and Steel Daily News* indicated that a discussion of the solids build-up upstream of the orifice plate would be reviewed. Originally, when this abstract was prepared, it was my intent to include it as part of the paper you have heard. However, a preliminary check of delivery time proved the paper to be too lengthy so that, to conform to the time limitation, I deleted that portion covering the build-up upstream of the orifice face. I am sorry this situation has occurred. However, we have made a fairly intensive examination as to what is happening in the vicinity of the orifice. On the P-3 furnace installation, after it had been in operation for about three months, we were able to take the washer out of service and look into the orifice duct. Downstream of the orifice no build-up was evident. There was a build-up on the upstream portion of the duct. This orifice has a 32 in. opening and is installed in a 6 ft gas main, with its spray water admitted 12 in. upstream of the orifice face.

The deposition began on the orifice face, about 6 in. from the orifice opening and filled the space over to the duct wall, rising irregularly upward to the point of water injection where it fell away to zero. The build-up resumed its occurrence a few inches above, or upstream of, the point of spray water admission and acquired its greatest radius about 30 in. upstream of the orifice face. At the most constricted cross section of build-up, however, the internal diameter was about 12 in. more than that of the orifice itself.

M. J. Conway: The distances mentioned, relating to the upstream and downstream pressure taps for P-3 washer on which the tests were made, are within a range to determine what the actual pressure drop could be, at the time when the water rate was 7 gal per thousand cu ft of gas. These tests show a pressure drop of 48 to 50 in. Therefore, the cleanliness attributed to this orifice scrubber was obtained at 48 to 50 in. pressure drop and not at the designed 30 in. pressure drop.

It is evident that the exit gas loadings are the result of this considerable difference in pressure drop, between design of 30 in. and 48 to 50 in. as determined by test.

T. J. Letter: The first orifice type washer at South Works was installed in December of 1957. We now have three furnaces equipped with this type of washer. Our results have been approximately the same as those reported in the paper.

Experience with water introduction has been limited to flow to the nozzles which are installed at the orifices. Our tests have shown that we receive the best results with water rates of 6 to 7 gal per thousand cu ft of gas.

We are experiencing higher pressure drops across the orifice than the 30 in. reported in the paper. We also found that the pressure drop on one furnace affected the operation of the bells when the furnace operated without high top pressure.

G. E. Reid: Since you have three orifice type washers in operation at South Works, have you been able to reduce to any extent the water flow to your conventional type scrubbers by virtue of the fact that you are now operating your orifice washers?

T. J. Letter: We have not reduced the water flow to the tower type scrubbers. We have run a very limited number of tests varying the water rates on these scrubbers but have no conclusive data to support decreasing the water rate to the scrubbers.

G. E. Reid: I think you will agree you do not need as much water on the tower scrubber as you did beforehand.

T. J. Letter: I have no data to support that conclusion.

N. R. Kirkdoffer: I am vitally interested in the utilization of blast furnace gas, and as a member of the Air Pollution Board of East Chicago, Ind., I am also vitally interested in reduction of air pollution.

At our plant No. 3 we have two of our blast furnaces equipped with venturi type scrubbers. The benefits realized by using gas cleaned by these scrubbers have been similar to those at J & L as reported in Mr. Reid's paper. Where we formerly cleaned the gas burners on our boilers twice a turn, we now find it necessary only once every two days. We formerly found it necessary to clean our gas lines and manifolds and the fire side of the boilers once every four months. This requires about 190 man-hours for cleaning the gas lines and approximately 130 man-hours for cleaning the fire side of the boilers. Based upon inspection of one boiler after six months in operation on clean gas, we feel that cleaning will be necessary only once a year and even then may require less labor than before.

The orifice type scrubber certainly has the advantage of simplicity and cost over the venturi type scrubber, but I would expect its power requirements due to the head loss to be greater than with the venturi scrubber. Mr. Reid stated that their orifice scrubbers were designed for 30 in. water column drop. Is 30-in. drop the optimum and what is the effect on scrubbers efficiency if a lower pressure drop is taken across the orifice?

G. E. Reid: We have made no comparative tests on a scale implied by Mr. Kirkdoffer's question so that I cannot state the orifice differential pressure drop that could be considered as optimum. Our orifices are designed to give a 30 in. water column drop under normal dry gas flow conditions. Under actual operation, due to spray water additions, this pressure drop is greater than 30 in.

W. O. Bishop: I am wondering in connection with the question, if the reason for the 30 in. was that, added to his normal clean gas main pressure, perhaps this was the limit at which he could dump the bells in his furnace without getting into trouble.

G. E. Reid: To the best of my knowledge we have not had difficulty with high furnace top pressures caused by use of the orifice washers.

C. H. Good, Jr.: U. S. steel has installed a limited number of both orifice and venturi type washers. Operating experience with these units leads us to concur with Mr. Reid's statement that dust loadings of

0.02 grain per std cu ft can be obtained and we further believe that, as we gain more knowledge of these devices, loadings of 0.01 grain are possible.

Mr. Reid has pointed out and I want to emphasize, that the installation of this type of high energy wet washer does not eliminate the need for the conventional spray tower on the downstream side since some type of large tower is necessary to permit cooling and water separation from the gas.

The performance of these orifice and venturi washers does indicate, however, that precipitators may not be necessary, in the future, for final gas cleaning.

Wayne Campbell, of U. S. Steel's research and development organization, has analyzed and summarized the U. S. Steel experience in a paper presented to the AIME in April of 1959. These data indicate that, for a given pressure drop, slightly cleaner gas can be obtained with a venturi type washer than can be had with an orifice type. Pressure drop, however, may or may not be important, depending upon the various other operating factors surrounding the particular installation.

At Fairless Works we have had a good opportunity to evaluate a venturi washer installation.

Our first two blast furnaces were equipped with the conventional gas cleaning facilities, consisting of dust catcher, tower scrubber and precipitators in series. The third blast furnace was equipped with all of these devices, plus a venturi washer upstream of the tower washer. One bank only of water sprays is used in the tower washer for gas cooling and separation.

The venturi, 42 ft 7 in. long, is inserted in a 9 ft diameter gas main and has a 7 ft 10 in. by 1-ft rectangular throat section. It is operated at about 45 in. of water differential pressure.

As to comparative performance, the outlet dust loading on the conventional tower washers at No. 1 and 2 furnaces averages 0.175 grain per cu ft with final cleanliness out of the precipitators averaging 0.005 grain per cu ft.

At No. 3 furnace, the combined venturi and cooling tower outlet dust loadings averages 0.020 grain per cu ft with the precipitator outlet loading remaining at 0.005 grain. ▲

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ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 Empire Building **Pittsburgh 22, Pa.**

54 Years of Operation of the First Electric Driven Reversing Mill

by GEORGE H. KRAPF,
Division Superintendent
Power Production
and ELMER I. PEARSON,
Assistant Works Engineer
South Works
United States Steel Corp.
Chicago, Ill.

. . . . United States Steel's pioneer electrical installation, a 30-in. reversing mill, has operated successfully since 1907 with only minor modifications, a tribute to engineering forethought and planning . . . .

AT the turn of the century, all industry in this country was being stirred by developments in that prodigy, the infant electrical industry. Technical society transactions record the extensive discussion of controversial subjects such as the replacement of steam powered elevated rapid transit car systems with electrical motor powered systems, and the relative merits of various types of overhead trolley and third rail collector systems.

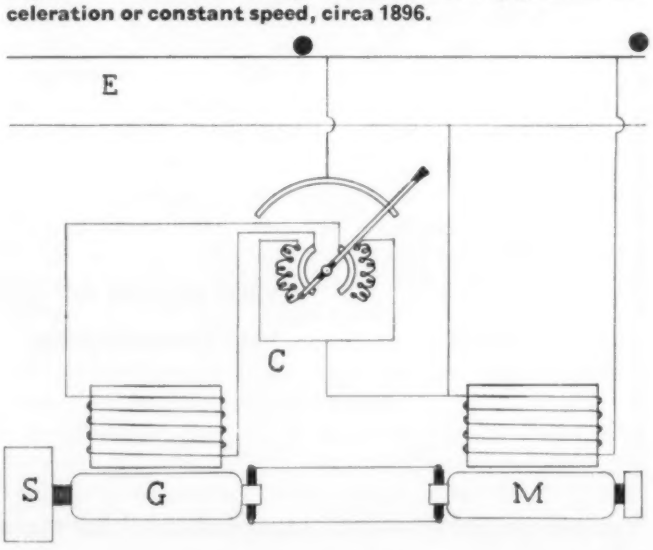
Another controversial topic of discussion of this period was a paper, "Volts Vs Ohms," presented by H. Ward Leonard at the 110th meeting of the AIEE at New York on November 18, 1896; with vice president Steinmetz in the Chair.

The object of this paper was to show the disadvantages of a constant potential ohmic control system, requiring power circuit resistors and contactors, as compared with the advantages of a newly developed generator voltage control system, requiring a rheostat to handle the comparatively small current of a generator field.

Figure 1, as depicted in Ward Leonard's paper, shows the variable voltage generator control arrangement. The underlying feature of this control system is to "insert or cutout emf instead of ohms in the armature circuit of the motor" when it is desired to change its speed.

Some of the discussions of the Ward Leonard system became rather involved, if not to say rather heated, at times. We quote from the 1896 *Transactions:* "I think we will all admit that the method of control exhibited here is very pretty. I am quite sure no motor armature can be controlled quite as nicely by any other method; but, as Mr. Dunn has just suggested, the whole question of its practicality is one of cost—not first cost, to my mind, but cost of operation. I doubt very much if the cost of operation of the apparatus of this kind can be brought down as low as with the more usual method of control. Every time this matter has come up before I have taken the position that this is the least economical method of operation, and I am still of that opinion. I saw Mr. Leonard's paper a day or two ago, and to get an idea of what was being done I have examined some of the plants in the city running with this general method

Figure 1 — Variable voltage control allowing gradual acceleration or constant speed, circa 1896.



of control, not precisely similar, but on the same lines as Mr. Leonard's method; and of one case in particular—that of the New York Clearing House plant—where an elevator is running on this plan, I wish to speak. Here are four small sidewalk elevators used for bullion, and having direct rheostat control in the armature, and one large passenger elevator with this motor-generator control. To run this plant there is an engine connected directly to a large dynamo of 50 kw supplying merely the power circuits, and not the lights of the building at all. A large part of the time only one passenger elevator is in use, and to run it there is the engine and large generator driving a motor, which in turn drives a generator with variable field; this in turn drives the hoisting motor; that is, a series of five pieces of machinery—one engine and four electrical machines are used for one elevator. The generating set has to run whenever the building is open, say from eight o'clock in the morning until six o'clock at night. That is, an engine of 75 hp with large generator runs 10 to 12 hr a day, most of the time doing nothing but friction work, but standing ready to supply power to the elevator whenever required. I venture to say, from observations that I made, that the ratio of work done on the elevators to the waste caused by the friction of the generator turning all the time is considerably less than one tenth; the all-day efficiency cannot possibly be 10 per cent."

Although many design engineers were reluctant to recognize and to accept the advantages of the new variable voltage control system, there were some far-seeing engineers. One of these was Charles P. Steinmetz. We quote Mr. Steinmetz from the same *Transactions:* "There are two features mentioned in this paper and inherent to the method, which have not yet been fully brought out. The one is the very gradual and easy start which may be made, irrespective of all questions of efficiency, which is of great advantage for passenger elevators—not so much for freight elevators. I remember a number of instances where this system was installed for first class elevator service in order to get a gradual and easy start.

"Another feature of this system is the ability to control the speed perfectly and to maintain it constant at a very low value, irrespective of variations of torque. This is a very important matter in certain instances, as for printing presses and so on, where it is necessary sometimes to run at very low but constant speed, which is not possible with rheostatic control, since by rheostatic control for very low speed, say 10 per cent of full speed, the speed fluctuates excessively even for small variations of load.

"Where a speed variation of only 25 per cent or so is needed, it can generally be accomplished by controlling the motor field, but very wide ranges of speed cannot be covered thus.

"In these two cases it is not so much a question of economy, or of efficiency, nor of the first investment, or the cost of operation, but the necessity of securing a method of very gradual acceleration, or a constant speed irrespective of torque, at a very low, as well as a high, value of speed."

Certainly, some of the outstanding characteristics of this new method of variable voltage generator control for motors, as stated by Mr. Steinmetz, were also recognized by some visionary steel mill engineers. These pioneers in design development were excited by the potential application of heavy duty, high hp electrical motor drives to replace steam powered main mill drives. Such installations were made practical only by the application of the variable voltage control method because resistors and contactors were not, and still are not, practical to handle peaking currents of 2500 to 10,000 or more amp.

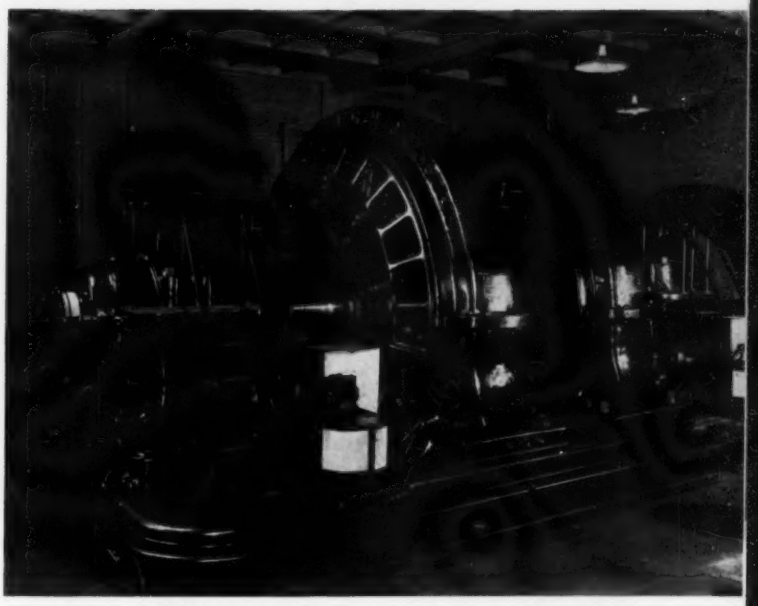


Figure 2 — A double-armature main drive motor was installed to reduce the flywheel effect.

Therefore, in the early 1900's at the South Works of the Illinois Steel Co. (now United States Steel Corp.), plant engineers and rolling mill operators and electrical manufacturer's engineers were collaborating in setting up an experimental rolling mill, powered by 76-A street railway type motors to roll small bars. The results of this experimental activity became evident in 1905 when designs were put on drawing tables to develop a 4000-hp main mill drive motor for a large rolling mill at South Works.

This motor and associated equipment was the subject of a paper published in the *Electric Journal* in 1908. The authors of this paper were W. A. Dick and B. G. Lamme. This is the same B. G. Lamme which the AIEE has honored each year since 1928 by awarding the Lamme Medal to a member for "Meritorious Achievement in the Development of Electric Apparatus or Machinery."

We quote rather freely from the *Electric Journal's* description, "this installation represents a novel and distinct innovation, both from the nature of the service requirements and from the size of the motors. They are by far the largest ever built in this country for such work (Figure 2).

"The mill is a 30-in. universal, reversible, plate mill with two high rolls, used for rolling plates and bars. The estimates on the power required to operate the mill, including reversing, were furnished by the engineers of the steel company. In general, the cycle of operations in rolling a typical piece includes 13 passes through the rolls, the speed of the rolls for the initial pass being 40 rpm. The torque required of a driving motor was approximately 300,000 lb at 1 ft radius for the initial pass. The hp required is about 2300 for the first pass and increases gradually up to the seventh pass, where it is

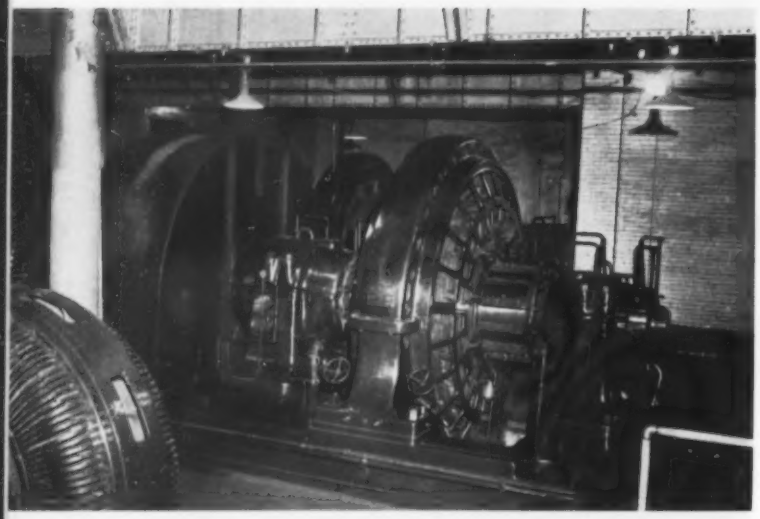


Figure 3 — The motor-generator set made use of a flywheel built up of dovetailed laminations to meet speed and safety requirements.

approximately 3500. A complete cycle, the time to roll a typical piece, is about 80 sec.

"The apparatus consists of a motor for driving the rolls of a mill, a motor-generator or equalizer set with a large flywheel for supplying power to the motor, and a system of control for operating the outfit. The mill motor has an intermittent rating of 10,000 hp at 575 volts (nominal nameplate rating of 4000 hp). It consists of two units (each having a nominal rating of 2000 hp mounted on a common shaft with common bearings and bedplate. In order to secure a motor that could be reversed quickly without an excessive expenditure of power in accelerating, it was necessary to adopt a two machine unit. With this arrangement, a much smaller diameter of rotor can be used and hence a reduced flywheel effect is secured. (The machine has 12 poles and a speed range in either direction of 0–100 rpm with full exciting field, and a speed from 100 to 150 rpm by motor shunt field control.) The contract called for a reversal from full speed in one direction to full speed in the other in three seconds. To obtain the rapid changes in field strength to secure such rapid reversals, the field circuits are laminated, being built up of thin sheet steel punchings supported by a cast iron frame. To secure good commutation over the extreme ranges of torque and speed, recourse is had to a compensating winding through the field poles to neutralize armature reaction, and to commutating poles to secure a fixed point of commutation. The punchings are made to include both the commutating poles and slots for the compensating winding. The shaft of the motor is hollow forged steel 28 in. in diameter in the armature spiders, 25 in. in diameter on the coupling end and 20 in. in diameter on the outside end. The bearings are 62 and 54 in. long respectively, have oil rings and forced oil lubrication and are water cooled. The bearing housing at the mill end is provided with a thrust collar and is especially strengthened so as to be able to withstand extraordinary shocks that would result should the mill shaft break.

"The operation of such a mill motor, if connected direct to a power house, would require amounts of power that would fluctuate over a wide range and involve a large power house and transmitting installation. By the use, however, of a so-called equalizer set (Figure 3) consisting of a generator to supply power to the mill motor, a flywheel and a motor to be operated from the line, a combination is obtained in which the load on the main power house is practically constant and equal to only the average taken by the mill motor.

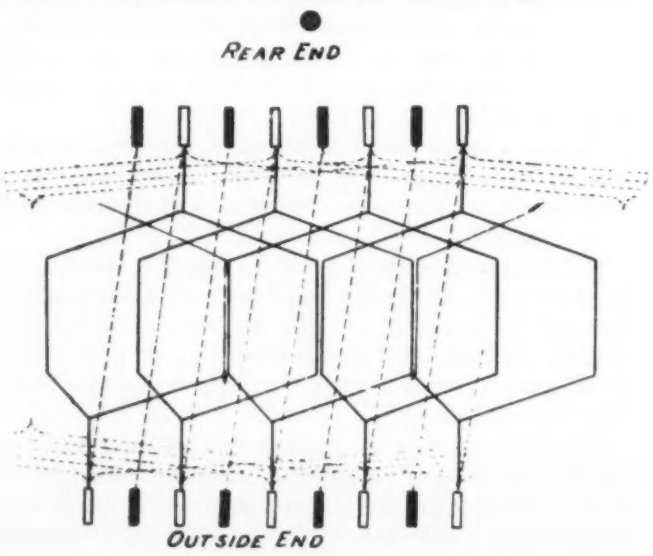
"The generator of this equalizer set is wound for 600 volts (normal capacity of 4000 kw) suitable for operating the mill motor. The field circuit is laminated and the compensating and commutating pole windings are the same in arrangement and construction." The generator armature coils are equalized (Figure 4) with the intermediate points of the coils being brought back to the commutator. There are two generator windings, each winding being connected directly to each motor armature. The roll motor armature coils are equalized similar to the generator windings.

"The flywheel of this equalizer set represents an interesting innovation in flywheel design. The requirements as to speed and weight were such as to preclude the use of a cast steel ring with safety. Resort was had, therefore, to thin sheet steel and the wheel was built up of this material, in the shape of punchings, dove-tailed to a cast steel spider with overlapping joints and bolted together between two outside steel rings by numerous bolts. By using sheet steel, the quality of the material in the wheel could be known definitely and a wheel of ample strength obtained. For convenience in assembling and shipping, the wheel of this set was built in two halves. The combined flywheel weight is 200,000 lb. The diameter is 13 ft 2 in., giving a peripheral speed of 258 fps at 375 rpm. The radius of gyration is 5 ft 2½ in. and the total flywheel effect is 5,320,000 lb at 1 ft radius. The induction motor is wound for 2200 volt, 3-phase, 25-cycle and has a continuous rating of 1300 hp."

The original control circuit for the a-c motor consisted of current transformers, relays, resistors, and 30 electric-pneumatic switches, etc., which were used to vary the rotor's secondary resistance. This was later modified as shown in Figure 5 in which the secondary control was replaced by a slip regulator.

To vary the generator field and motor field resistance, two Dinkey type face plate controllers were used, as illustrated in Figure 6. The piston shown is a mechani-

Figure 4 — Generator armature coils are equalized with intermediate point brought back to the commutator.



cal device to prevent the operator from moving the controller too fast. Controllers were interlocked so that full generator field must be obtained before the motor field could be weakened. The generator field controller shown in Figure 6 is the original controller, furnished with the equipment in 1907.

Because this equipment was novel and a distinct innovation, there was considerable discussion of the merits of steam versus electrical drives, as well as the electrical components making up the complete electrical installation. To meet the criticism, and comments of the day, the authors of the paper prepared a summary which we quote herewith.

SUMMARY

"In studying an installation such as is described above, and comparing it with the steam engine drive which it supersedes, the question is apt to suggest itself, is not such a system rather complicated and expensive? It might appear so at first sight, and yet the answer to such an objection appears in the advantages of the electric drive over the other.

"Briefly these may be stated as follows:

Increased output.

Simplicity and ease of control.

A noticeable reduction in the number of attendants required.

Figure 5 — Original control circuitry was modified with the installation of a slip regulator to facilitate secondary resistance variance.

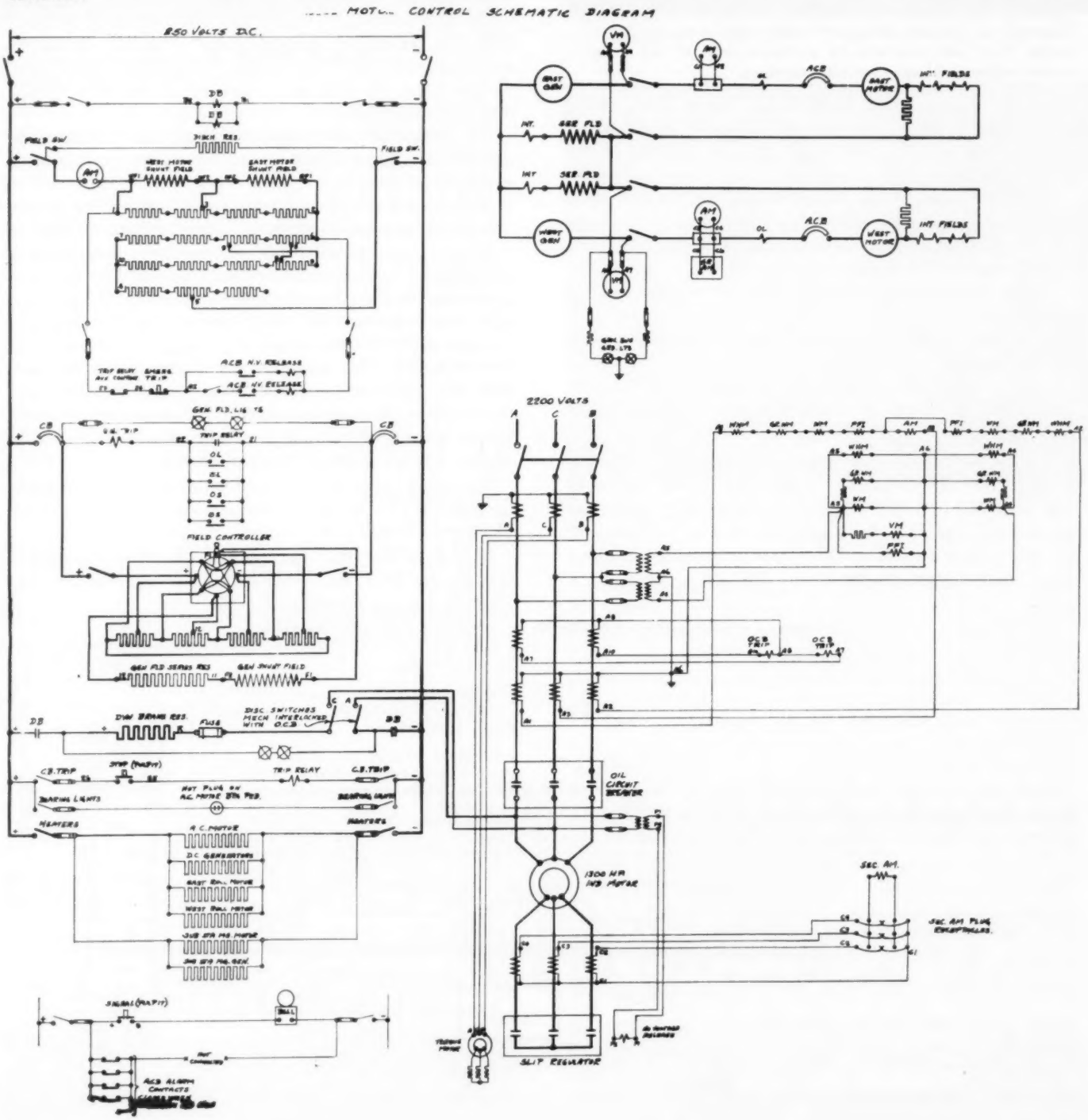


Figure 6 — The face plate controller used to adjust the generator field was retarded by a mechanical piston attachment to limit the speed of adjustment.

The concentration of the boiler plant in one place where steam is used, the central plant being much smaller than a number of isolated plants would be.

Where blast furnace gas is available, the ability to do away with the boiler plant entirely and use gas engines driving electric generator.

Decreased floor space.

Decreased power required through using equalizer sets.

Ability to measure power used accurately by recording instruments.

Wear and tear in the mill is lessened, as it is noticeable that the shocks due to reversals, etc., are much less severe with the electric drive.

"All of which result in a material decrease in cost of production. The consensus is that the above solution of the problem of electric drive for reversing mills has passed the experimental stage, and that an extension of its use is sure to follow. The results already obtained have been very gratifying."

In giving tribute to the designers of the electrical equipment for the main roll drive for the 30-in. universal plate mill, we would be remiss if we did not also give tribute to the pioneers who conceived and designed the necessary electrical drives for mill auxiliaries and cranes to make this an all electric mill. Figure 7 outlines the principal operating units including the slab yard, reheating furnaces, screwdown, tables, levelers, etc.

This mill one of two universal plate mills in United States Steel, which mills have vertical as well as horizontal rolls, provides rolled edge sections which are used in some applications where sheared edge sections are not desired.

The mill has served this country's requirements through two world wars, and the Korean action.

Since the original mill installation went into service July 26, 1907, only minor repairs were made until the year 1955 when the 1300-hp motor of the motor-generator set was rewound. Finally, in 1958, a series of grounds indicated advanced deterioration of motor armature coil insulation, requiring rewinding of both armatures. At this time, the mill had rolled approximately 6,062,000 tons of product.

An outline of the rewind schedule was prepared for the dismantling and reassembly to assure proper utilization of manpower.

This motor required a number of interesting procedures due to close working quarters and the method of original assembly. The limited head room and the lack of sufficient overhead crane facilities required that the armature be raised and cribbing provided to get the field structures out. The field frames were then sent out to have all field coils reinsulated. Figure 8 is a view of the situation. The construction of the motor requires that the equalizer stubs be completely finished and banded into place before any of the armature coils can be put into the slots, as indicated in Figure 9. Figure 10 depicts one phase of the rewinding work.

We would now like to read an excerpt from a plant magazine, *The South Works Review*, dated April 24, 1924.

"On July 26, 1907, the present electrical equipment driving the 30-in. universal plate mill rolls was put into

Figure 7 — General plan of the 30-in. universal plate mill building.

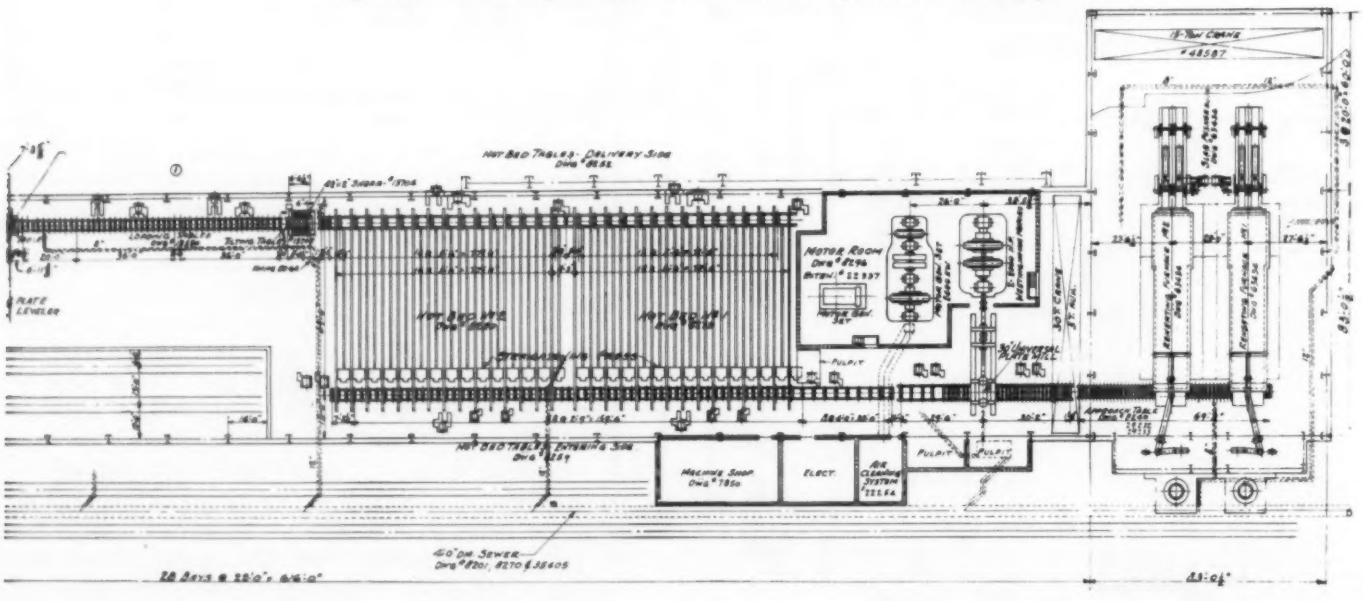


Figure 8 — Removal of the field frames required that the armatures be raised and blocked in position, since there was no available crane service.

continuous operation after two or three months' experimental operation, testing and adjusting. This equipment, consisting of an a-c motor and d-c generator flywheel set, and two reversing d-c motors driving the rolls, was the first of its kind to be built and installed in this country. The same type equipment was developed at about the same time in Germany.

"This equipment is now finishing its 17th year of service and has given very little trouble. It is operating satisfactorily and the end of its useful life is apparently far in the future. It is a tribute to the designers who, in building an experimental machine, with no precedents to work from, produced an equipment that has given such good service, and has not been relegated to the scrap pile of obsolescence by the rapid developments of the electrical science during the last 20 years."

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Transactions, American Institute of Electrical Engineers, Volume XIII, 1896.
South Works Review, April 24, 1924.

Discussion

PRESENTED BY

I. N. TULL, Electrical Superintendent, Cleveland District, Republic Steel Corp., Cleveland, Ohio

E. I. PEARSON, Assistant Chief Works Engineer, South Works, United States Steel Corp., Chicago, Ill.

J. D. O'ROARK, Assistant Manager, Dept. of Service and Maintenance, Electrical, Div. of National Steel Corp., Weirton, W. Va.

C. G. DIMITT, Supervisor, Electrical Design Engineering, South Works, United States Steel Corp., Chicago, Ill.

B. E. CARLSON, Electrical Service Supervisor, Westinghouse Electric Corp., Chicago, Ill.

G. H. KRAPF, Division Superintendent, Power Production, South Works, United States Steel Corp., Chicago, Ill.

I. N. Tull: I do not know that there is much to add to a paper which describes so eloquently the fundamental concept of the driving force that was

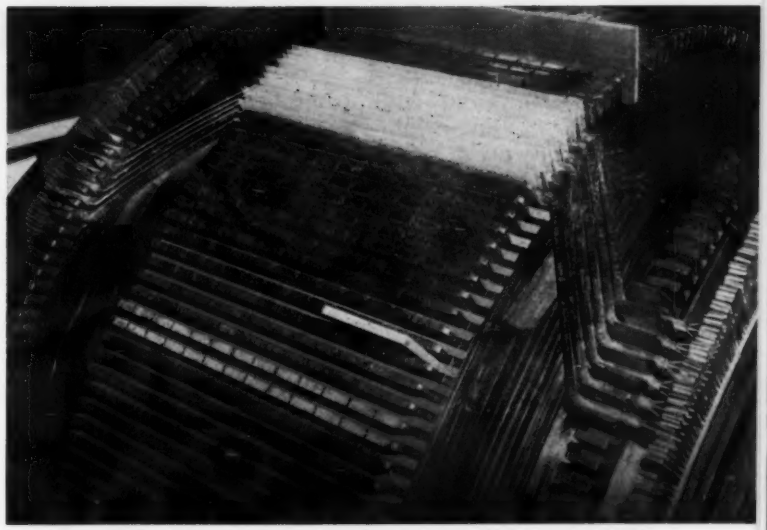


Figure 9 — Equalizer stubs must be completely finished and banded into place before armature coils can be put into slots.

Figure 10 — Rewinding of the armature was accomplished on the site.

required to put on the rolling mill in those early days. We usually try as time goes on to see if we cannot replace an old horse with a new one. This one looks as if she is good for some time, provided the mill is. They probably stuck on some new type brush holders and a few new brushes.

I am wondering how the mill compares with the motor itself and if you have any concept of the length of time you are going to keep it in service. I suspect from the looks of it that 46 years from now it will still be going strong, which will make an even 100.

E. I. Pearson: The electric drive equipment for that mill is in such good shape that, as Mr. Krapf mentioned, it should last another 50 years. The mill was originally built for carbon steel plates and bars only. Today's product for that particular mill is up into the alloy range and we are having considerable difficulty in keeping the rest of the mill up to the drive equipment.

J. D. O'Roark: I would like to ask some questions about the rewinding details. In the first place, what type of insulation was on the original coils? The next, were the mica "V" rings, front and back, of the commutator still in good enough shape that you had to do

no reconditioning of the commutator? Was the commutator wear such that it had not lost too much of the original depth of the bar so that it was still good for another 50 years? Also, what type of insulation did you use in the winding as compared to the original insulation?

One more question. What was the approximate degree of loading on the motor during that 50 some odd years of operation?

C. G. Dimitt: The coil insulation originally was sheet mica which was molded to fit the bars. It was not a tape mica. We do not think tape mica was available in those days. Secondly, as to the "V" rings, we do not believe they were replaced.

B. E. Carlson: They were not replaced.

C. G. Dimitt: About reconditioning the commutator. We have not hit anything but normal reconditioning occasionally, which you would expect from brush wear. These are still the original commutators. They have not been replaced. As to the thickness of the bars, assuredly there was enough material for the first 50 years, and we expect the commutators to last the life of the machine. If this is another 50 years, the last few years might be a little thin, but we expect to get by satisfactorily.

E. I. Pearson: We were asked something about the loading on the mill. The speed of the mill has been restricted to some extent in that while the equipment originally was designed to operate with generator voltage and with field weakening, we have been using it with full generator voltage only. With a base speed range of zero to 100, we have never found it necessary to run the mill any faster. We can do everything necessary at base speed.

As to the load, it has not been limited, if that is what you mean. Originally this was a 575-volt machine, technically 600 volts. We are running at approximately 500 volts. So, to that extent, we have retrenched from 575 to 500 volts.

B. E. Carlson: The original insulation was, as stated, mica on the slot portion and varnished cambric on the diamond portion, and the coil was then wrapped with cotton tape. As the coils were reinsulated, sheet mica was used on the slot portion. Glass tape was used throughout in place of the cotton tape.

As far as the commutator is concerned, this machine is 100 per cent equalized. We found approximately seven risers broken. Commutation was not affected by this, but they were repaired and put in proper order.

We found two shorts in the commutator that had to be dug out to a depth of about the length of a pocket knife. These were packed with sheet mica and shellac and insulated over the top. This was about the extent of the repairs to the commutators.

The commutators looked very good. In my opinion, they have another fifty years of service in them.

G. H. Krapf: The cost of the rebuilding operation was approximately $110,000 to do this job. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

No September meeting

BUFFALO SECTION

No September meeting

CANTON SECTION

No September Meeting

CHICAGO SECTION

No September Meeting

CLEVELAND SECTION

No September Meeting

COLORADO SECTION

Tuesday, September 20, 1960—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Stretch Reducing Mill Operations," by C. C. Crawford, Superintendent, Seamless Tube Mill, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

No September Meeting

LOS ANGELES SECTION

No September Meeting

PHILADELPHIA SECTION

No September Meeting

PITTSBURGH SECTION

No September Meeting

ST. LOUIS SECTION

Wednesday, September 21, 1960—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"European Metal Rolling Practices," by T. H. Bloodworth, Chief Engineer, Industrial Systems Dept., The Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Tuesday, September 20, 1960—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Judson Steel Corp. Night

"The Crossing at Glen Canyon," by Wm. T. Egan, Sales Manager, Yuba Consolidated Erectors, Inc., San Francisco, Calif.

Spengers Restaurant, Berkeley, Calif.

UTAH SECTION

Monday, September 12, 1960—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

Details Not Available.

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

No September Meeting

HIGH SPEED ROD ROLLING

Four strands at speeds up to 400 fpm presented problems requiring patience, understanding and technical knowledge.

by E. L. CHAMBERLAIN,
Division Superintendent, Hot Mills,
Cuyahoga Works,
American Steel and Wire Div.,
United States Steel Corp.,
Cleveland, Ohio

THE new No. 1 high-speed rod mill was installed at the Cuyahoga Works in 1956. It recently set a new 24 hr record of 2105 tons and a weekly record of 11,399 tons.

Figure 1 is a schematic drawing of the layout of the mill which was built 14 ft above ground level so as to be able to accommodate oil storage, reel pits, scrap disposal, locker rooms and other auxiliary equipment on ground level rather than in basements.

Steel is received in 10 to 15-ton chain lifts via gondola cars and trucks, and is stored in two adjacent billet yards (Figure 1). The billets are $3\frac{1}{4} \times 3\frac{1}{4}$ in. $\times$ 30 ft long and weigh approximately 1050 lb. Eventually, all billets will be 34 ft long and weigh 1200 lb. Combined storage capacity of the two yards is about 58,000 tons.

Billets scheduled for the mill are placed on the billet unscrambler (Figure 2) directly from storage or gondola cars. The unscrambler has two sets of oscillating skids located between stationary skids, which separate and aline the billets before they enter the furnace feed table trough. From there they are pushed into the furnace by a charging car. Any combination of billets from one through four may be charged to the furnace at one time. An automatic billet counter records and totals the number of billets entering the furnace.

The furnace will hold 250 billets and is of the two-zone, side-charge and discharge type, with a capacity of 100 tons per hour. It has an effective hearth area 38 ft wide and 70 ft long. Generally, natural gas and/or coke oven gas is used as the fuel for heating, but oil has also been used successfully. The fuel consumption is approximately 250,000 cu ft per hr at capacity (1,500,000 Btu per ton of steel).

Billets are charged to the mill through the use of an electrically operated "peel or pusher bar" operating on oil-hydraulic cylinders. This entire unit travels the width of the furnace discharge door, in order to line up the bar with any of the possible billet positions in the furnace.

Reversible pull-out rolls (Figure 3), located on the mill side of the furnace, aid the charging of billets to the mill. These rolls may also return a portion of a billet to the furnace in the event of a cobble in the roughing mill.

The four-strand mill consists of a maximum 23 stands for continuous rolling operations or 17 stands maximum for semi-continuous or looping operations. A speed of 6400 fpm is possible, when rolling continuously. The main "breakdown" sections of the mill consist of a five-stand first roughing mill, a four-stand intermediate roughing mill, a six-stand intermediate finishing mill, and an eight-stand finishing mill for continuous rolling—or a two-stand finishing mill for semi-continuous rolling. A total of 13,500 hp is used to drive the mill.

The finest and coarsest size rods are produced by continuous rolling, and intermediate sizes are produced on the semi-continuous mill. The size ranges produced continuously are No. 5 rod through $\frac{27}{64}$ in. and $1\frac{5}{32}$ through $1\frac{1}{2}$ in. Intermediate sizes from $\frac{7}{16}$ through $1\frac{1}{8}$ in. are produced on the semi-continuous mill.

The looping mill is equipped with rotary disk dividing shears which are designed to cut and switch the rod

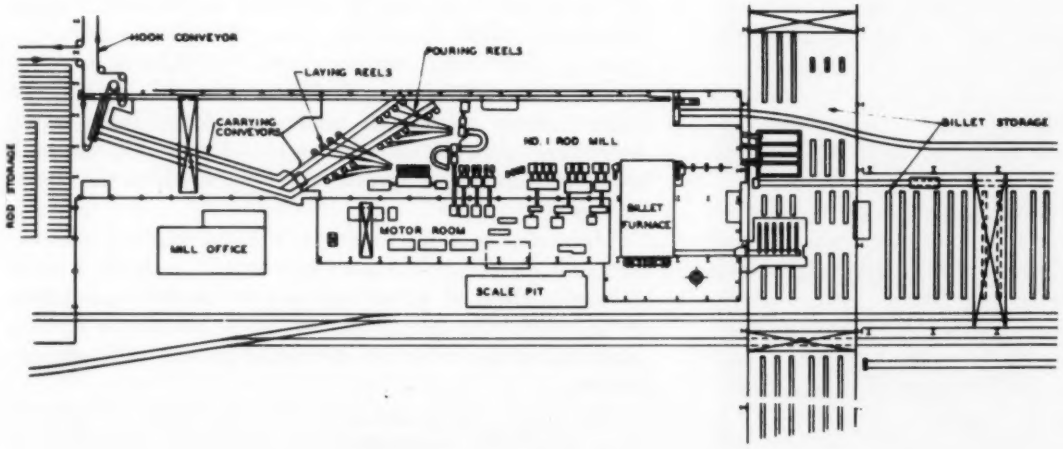


Figure 1 — General arrangement of the rod mill illustrates the well-planned flow pattern.

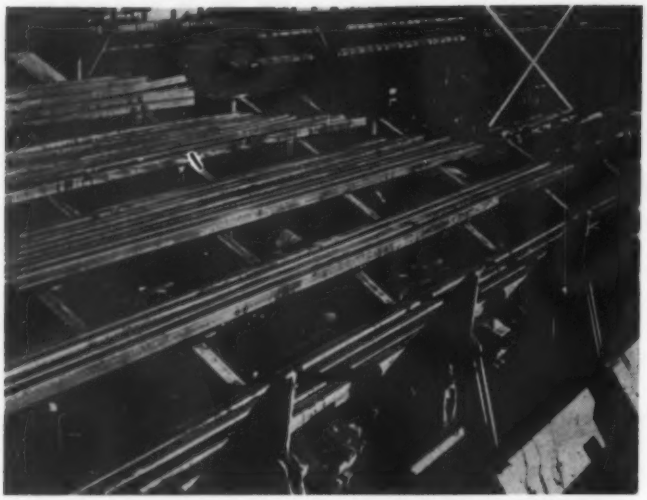


Figure 2 — Billets are separated and alined on a billet unscrambler.

Figure 3 — Reversible pull-out rolls can return part of the billet to the furnace in case of a cobble.

in one motion. Therefore, it is possible to supply customers with either 500 or 1000-lb bundles.

The roll housings are all of closed top construction and are equipped with oil-film bearings and parallelogram devices for axial adjustment of the bottom rolls. All mill screwdowns are operated by hand ratchet wrenches as shown in Figure 4, with the exception of No. 1 stand, where a motor drive is employed on each screw. To facilitate roll changes, each mill position has two complete roll housings so that the rolls can be set up in advance for the next size change because of worn passes.

A crop and cobble shear for each line is located between the second roughing and the intermediate finishing stands. These shears go from stop position to rod speed and back to stop in one cycle. Their function is to crop the front ends of the process bars, and cut the process bar into short lengths in the event of a cobble.

Eight enclosed laying reels are utilized in coiling No. 5 rod through $^{27}/_{64}$-in. rod, and eight pouring reels for coiling coarse rod, running from $^{7}/_{16}$ through $1^{1}/_{8}$ in. Two special reels are used for rod measuring $1^{5}/_{32}$ through $1^{1}/_{2}$ in.

Two drag conveyors serve both the laying and pouring reels. These conveyors in turn deliver the coils to the hook conveyor, which is approximately one mile in length. The lengthy hook conveyor is necessary to allow the rods to cool before reaching the inspection department. All inspection, trimming and banding of coils is done while the coils are traveling on the hook conveyor. This is no simple matter when one stops to consider that as many as 200 coils may be processed in one hour. Inspection consists of upset, etch, nick and break and magnaglow testing. The coils are then removed from the hook conveyor at any one of five unloaders (Figure 5).

The rod bundle unloaders are designed with two rams and a transfer conveyor. While one ram is indexed in line with the hook conveyor and strips rod bundles from the hooks, the other ram is lowered into position and deposits its lift of bundles on the transfer conveyor. An overhead crane carries the lift away from the transfer conveyor with a "C" hook for direct shipment to the trade or for storage for the wire mill.

That, very briefly, is a description of the mill and how it operates. The following will cover a few major problem areas that were encountered.

The eight-stand finishing mill in general, including guide design and material, making No. 5 rod at 6000 fpm and coiling low carbon No. 5 rod were the biggest problems.

The grinding, setting and analysis of the friction guides proved to be more critical than experienced on the old slower speed rod mills. Because of the additional friction heat, guides would "pick-up" more readily, and cause a cobble. This pick-up was common to both oval receiving and twister guides. Many different guide designs, methods of grinding and guide material were tried before a solution was found.

Bronze receiving and twister guides in the finishing mill have proved to be the best material. Grinding the oval receivers with as short a bearing area as possible keeps pickup down to a minimum. Increasing the degree of twist and improving the design of the nose of the twister guides also helps to reduce cobbles.

Running at these high speeds, the guides have to be set perfectly on the hole. A guide even slightly off the pass will give trouble further along in the mill.

It was found that the installation of roller twister guides, in conjunction with bronze twisters and bronze receiving guides, increased friction guide life, reduces mill cobbles and generally stepped up our rolling efficiency. From a quality and yield point of view, because of the high rate of production, keeping the mill in top rolling condition at all times became even more important. The operating crews became pseudo engineers, improving methods and procedures to stay ahead of the 6000-fpm mill. They learned to adjust the roller twister guides to maintain proper twist when four bars were in the mill and to keep all the mill sections uniform, in spite of the long reach to the inside strand.

Maintaining a fixed metal line throughout the entire mill also was found to be very important. This is normally checked when rolls are set up for installation in the mill. To insure maximum accuracy, a surface gage was designed to set the roll at precisely the proper height.

The snap shears ahead of No. 16 stand (Figure 6) were originally designed to be operated manually by

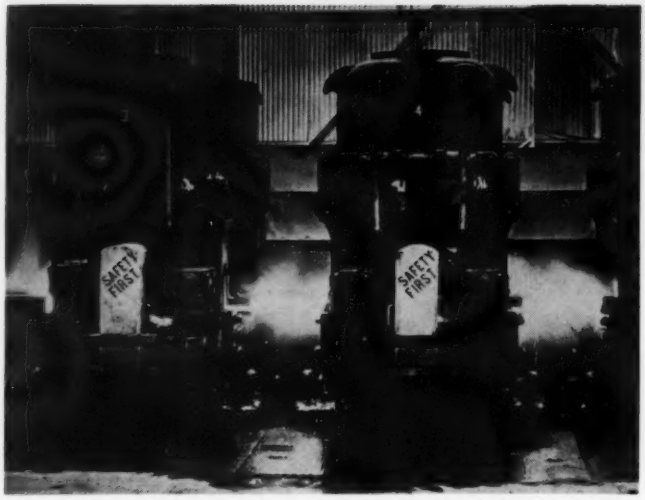


Figure 4 — Screwdowns are adjusted by ratchet wrenches throughout the mill train from No. 2 stand on.

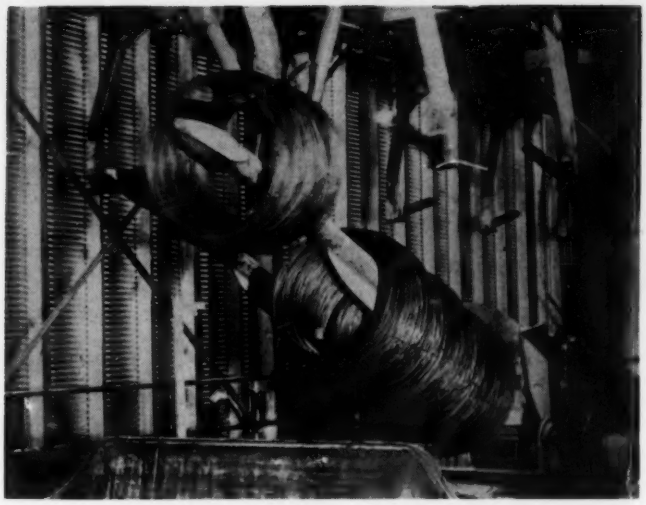


Figure 5 — Unloading of the hook conveyor is accomplished by any one of the five 2-ram unloaders.

the motorman or one of the finishing mill crew. With four lines going through the mill, it was very difficult to tell which one of the lines was cobbling. Since the stands are closely coupled, a cobble in one line often would knock out the other three lines. Consequently, removing a cobble became a serious problem. In some instances, the mill would have to be shut down and the overhead crane used to remove the cobble. To correct this, four photo-electric cells and a timer have been installed behind No. 15 stand (Figure 7). If the bars being rolled do not reach the switching cell within a given time, the shears will automatically cut, thus reducing the amount of scrap between the stands.

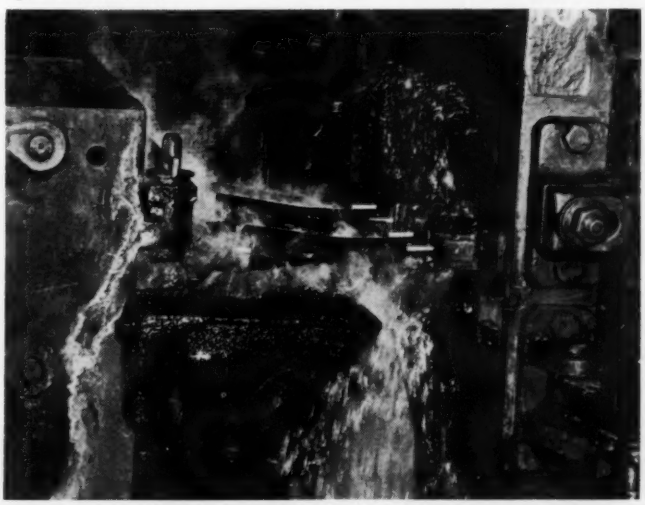
The laying reel pipes originally were ¾-in. inside diameter water-jacketed pipes, which extend out about six feet from the last finishing stand and thence into vertical air-operated switches. Beyond this point, are 1¼-in. inside diameter high pressure descalers and water eliminators before going into more 1¼-in. inside diameter water-jacketed pipes. The radius of the curved pipes entering the laying reels was about 6½ ft which was about 55 in. above the metal line of the finishing mill.

It was found that on No. 5 rod high carbon, and on all grades of steel for sizes greater than No. 5 rod, little or no difficulty was encountered delivering into the laying reels. But, while rolling low carbon No. 5 rod, there were mysterious cobbles which could not be explained. It was possible to reduce cobble frequency somewhat by installing ½-in. inside diameter pipes on the delivery side of No. 23 stand. However, performance still was not satisfactory, so the vertical switches were replaced with horizontal switching, having simplified mechanical design for more positive switching action. As shown in Figure 7, water eliminators were added to prevent the rod cooling water from passing under the electric eye. The reel pipes were lowered so that the curved pipes leading into the reels had a radius of approximately 32 in., which is about 1 in. above the metal line of the mill. Finally, the ¾-in. inside diameter water-jacketed pipes were replaced by short ¾-in. cast iron pipes from the switches to the curved pipes. This combination has provided the best results to date. Eventually, it is hoped to install short curved cast pipes delivering into the reels.

The high finishing speeds of No. 1 rod mill opened a new door for roll material analysis. A tough, and possibly harder, composition is needed to withstand the high temperatures and rolling speeds.

It was natural that the introduction of a mill of such speed and capacity (Figure 8), would pose problems of orientation and adjustment for the crews. Many of the men had worked on a single-strand mill—2200-fpm maximum delivery speed; some had experience on a three-strand mill with speeds of 3200 fpm maximum. However, the 6000-fpm speed presented a challenge, which has been successfully met. So well have the crews adjusted to the mill, that they are now able to pull cobbles and set guides while other strands still are rolling. The need of adjustment did not end with the operating crews. The technical background of the maintenance crews had to be developed further to keep pace with the modern mill design. The engineering department developed and utilized automatic controls insofar as practicable to reduce material handling and increase production efficiency. The level of performance of the responsibilities associated with No. 1 rod mill had to be streamlined to meet the mill's production potential. The mechanization of the

Figure 6 — Strand cobbling often disrupted the other strands due to their proximity. An automatic device now operates shear.



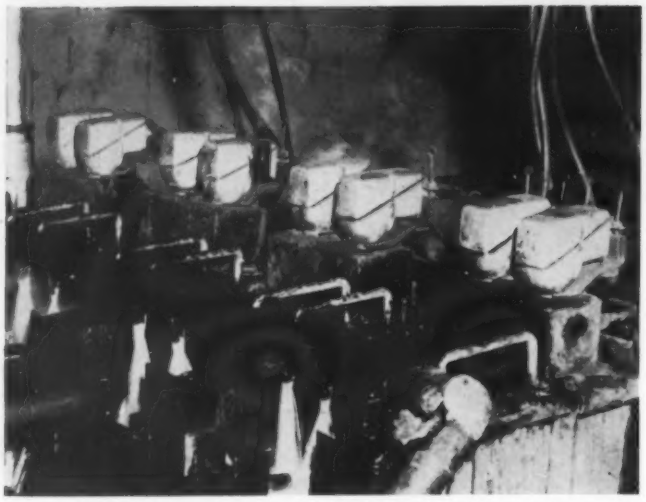


Figure 7 — Photo-electric cells are used to detect the presence of a cobble.

accounting and production planning system is presently being installed to furnish operating statistics and schedules necessary for more efficient operations. New problems relating to temperatures, structures of steel and testing procedures needed to meet customer demands had to be solved by the metallurgical department.

The combination of four strands at 6000 fpm represented a break-through of technical ceilings, and the patience and understanding of supervisory and executive responsibilities proved to be an important asset during the early period of mill operations.

As a result, production has been on a positive slope. In February, 1959, an average 515 tons per turn for 75 consecutive turns was achieved. Furthermore a new 24-hr record of 2105 tons, and a weekly record of 11,399 tons have since been established.

For those interested in individual eight hr records by sizes, they are as follows:

Size	Total tons
No. 5 Rod	648
5/16 in.	670
11/32 in.	732
3/8 in.	691
27/64 in.	790
17/32 in.	780

Figure 8 — Cuyahoga Works' No. 1 rod mill has continued to set new production records.

Even in the face of this performance, the optimum efficiency of No. 1 rod mill has not been reached. That has been proved by the March tonnage of 551 tons per turn for 83 consecutive turns; and a total of 45,734 tons for the month.

Discussion

PRESENTED BY

C. M. COE, Superintendent, Steel Div., Continental Steel Corp., Kokomo, Ind.

E. L. CHAMBERLAIN, Division Superintendent, Hot Mills, American Steel & Wire Div., United States Steel Corp., Cleveland, Ohio

J. L. EDWARDS, Consulting Engineer, Pittsburgh Steel Co., Monessen, Pa.

J. R. HARMON, Turn Foreman, Bar Mills, Cleveland District, Republic Steel Corp., Cleveland, Ohio

L. S. KLISZAK, Instrument Foreman, Wickwire Spencer Steel Div., Colorado Fuel and Iron Corp. Buffalo, N. Y.

C. M. Coe: How often do you polish passes?

E. L. Chamberlain: We have been polishing passes about every one and a half to two hours. When we polish passes, we stop the lines going through the mill to enable the finisher to polish both top and bottom passes.

J. L. Edwards: I would like to know the temperature your drive rod passes from the finishing stand to the reels? What pressure hydraulic water you use?

E. L. Chamberlain: From the last pass to the reel, we have a drop of 225 to 300 F depending on the grade of steel being rolled. The hydraulic water pressure is about 80 psi. The rod temperature increase going through the last eight stands is about 100 F.

J. R. Harmon: I would like to know the methods you use for cropping the coil ends? How do you tie the coil? Do you wire them or band them?

E. L. Chamberlain: On the finished coil we are using hydraulic shears to trim the bundles on the heavier sizes.

We put two wire bands on manually for our own wire mill and, on customer rods, we put three bands on each coil. We have been trying to develop a method to automatically band the coils with either wire or strap. We have not been successful to date. The conveyor goes about 40 fpm on 1000-lb coils. When we split the coils into two of 500-lb, it goes 60 fpm. Getting a machine to band material going at that speed is quite a problem.

L. J. Kliszak: A statement was made about picking up friction heat. Would you elaborate on how you pick it up?

E. L. Chamberlain: We pick up about 100 to 150 degrees F from our No. 10 stand through No. 23 stand. At the speed we are traveling, the heat is picked up from our friction guides and from the deformation of the sections as they are being rolled. ▲

ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ENGINEERS

1960

Cleveland Public Auditorium • Cleveland, Ohio

TO THE MEN OF THE STEEL INDUSTRY:

The prolonged slide in production rates over past months has put an increasing strain on steelmen to operate on the profit side of the ledger. Increasing competition from "glamour" metals, and the ominous threat of foreign steel imports add to the challenge that confronts us.

As always, the primary objective is more steel of better quality at lower cost, whether by new equipment or processes, new ideas, or new approaches to old ideas. The significant steelmaking advances of the past decade show what can be done.

At the 1960 AISE Convention and Exposition, you and your men will have the opportunity to see the latest products of suppliers. You will hear technical papers by leading authorities. Also, you will meet other steelmen who share your problems and your objectives. Through the years, the mutual exchange of ideas resulting from these meetings has been of immeasurable value to the individual, his company and his industry.

Join us at this year's convention in Cleveland.

S. C. READ President, AISE

SEPTEMBER 27 28, 29, 30

PREVIEW

IRON AND STEEL EXPOSITION
AISE ANNUAL CONVENTION

The 1960 Iron and Steel Exposition and the Annual Convention of The Association of Iron and Steel Engineers have been programmed for the specific purpose of keeping steel industry personnel informed regarding new processes, new techniques and new equipment.

Four full days of technical sessions will present the latest developments in steel mill theory and practice. All technical papers relate specifically to the iron and steel industry and have been prepared by authorities in this field. The program, in detail, appears on pages 4 and 5.

Four large halls will contain the exhibits of 212 leading steel mill suppliers representing the "blue book" of American heavy industry. No other exposition offers such a concentration of products specifically designed for steel company needs and requirements. Several outstanding exhibits will be of particular importance.

Steelmen who attend the Convention and Exposition will learn of many things to assist them in the better performance of their job. A steady increase in attendance gives testimony to the technical value of this activity. Over 15,000 will attend this year.

Invitation-tickets are being distributed throughout the iron and steel and allied industries. They may also be obtained from the Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh 22, Pa. AISE membership is not required and there is no registration fee for the Exposition or technical sessions.

IRON AND STEEL EXPOSITION HOURS

September 27—Tuesday, 10:00 am - 10:00 pm
September 28—Wednesday, 10:00 am - 10:00 pm
September 29—Thursday, 10:00 am - 5:00 pm
September 30—Friday, 10:00 am - 4:00 pm

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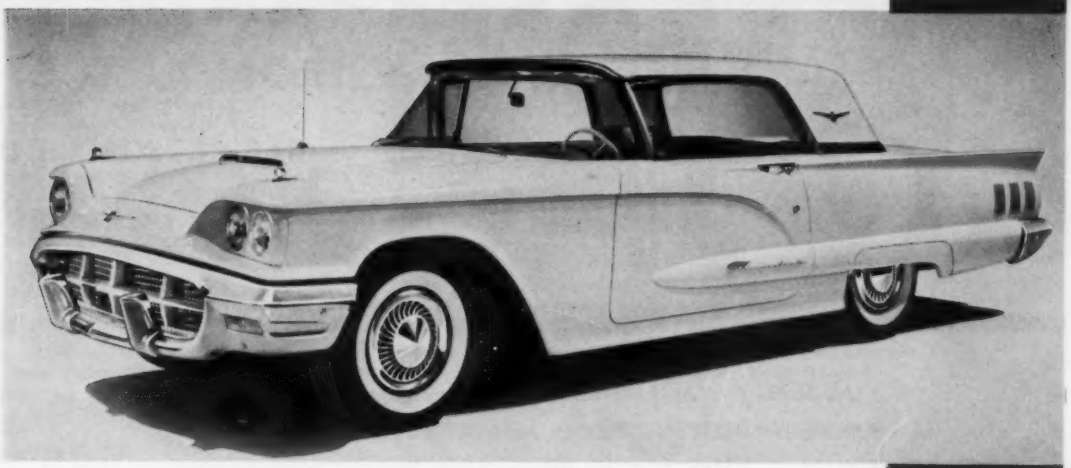
NO REGISTRATION FEE

TRANSPORTATION

Cleveland, Ohio, is readily accessible by all means of public transportation. The Ohio Turnpike offers fast automobile travel.

For those within the 150 to 200 mile radius of Cleveland, it is suggested that charter arrangements be made with a bus company to provide group transportation from plant locations to the Exposition-Convention.



A free chance on a 1960 Ford Thunderbird will be given to each man registering at the Iron and Steel Exposition.

The most recent developments of steel mill suppliers will be on display in the four big convention halls . . .

. . . and interest is high among steelmen ever alert for new ideas and applications.

The technical sessions which present the thinking of authorities in the industry, and the post-paper discussions bring the registrant factual and experienced information on plant engineering and operating procedures.

The formal banquet, held at The Statler Hilton, is an annual highlight of the Convention.

PROGRAM

1960 AISE CONVENTION and IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

Tuesday, September 27

9:00 am—REGISTRATION—Main Lobby

9:15 am—BUSINESS MEETING—Ballroom

Conducted by President S. C. Read

9:30 am—COMBUSTION SESSION—Ballroom

Chairmen: Edward W. Fitch, Chief Combustion Engineer, Republic Steel Corp., Youngstown, Ohio.
Stephen Vajda, Process Development Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Techniques in Rebuilding Open Hearth Furnaces" by Carl F. Bessent, Supervisor of Maintenance, Mechanical Maintenance Dept., Bethlehem Steel Co., Sparrows Point, Md.

"Evaluation of Checker Design" by F. D. Nelson, Assistant to Manager, Steel Production, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"A Comprehensive Method for the Thermal Design of Regenerators" by J. W. Hlinka, Senior Research Engineer, F. Puhr, Research Engineer, and Dr. V. Paschkis, Professor, Mechanical Engineering and Director, Heat & Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

9:30 am—LUBRICATION SESSION—Club Room B

Chairmen: Norman A. Bracht, General Foreman Roll Shop, Alan Wood Steel Co., Conshohocken, Pa.
Robert L. Humphreys, Assistant Master Mechanic, Bethlehem Steel Co., Sparrows Point, Md.

"Test Stand Evaluation of Oil Film Roll Neck Bearings" by Norman A. Wilson, Manager of Research, and Samuel S. Rickley, Chief Engineer, Morgoil Bearing Dept., Morgan Construction Co., Worcester, Mass.

"Grease on Tap" by Charles A. Bailey, Lubrication Engineer, National Tube Div., and Donald R. McCaa, Product Manager, Standard Products Dept., American Bridge Div., United States Steel Corp., Pittsburgh, Pa.

"Oil Mist Lubrication on Antifriction Backup Roll Bearings" by C. W. Southerington, Chief Engineer, Dallas Div., Revere Copper and Brass, Inc., Chicago, Ill.

2:00 pm—OPERATING PRACTICE SESSION—Ballroom

Chairmen: A. B. Glossbrenner, Superintendent-Conditioning, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.
John H. Stone, General Superintendent, Flat Roll and Tubular Products, Youngstown Sheet and Tube Co., Youngstown, Ohio.

"New Inspection Techniques and Their Effect on the Mill Operator" by G. P. Michalos, Superintendent of Inspection, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

"Analysis of Today's Tube Welding Processes" by Norbert C. Rubin, Vice President, The Yoder Co., Cleveland, Ohio.

"Applying Clear, Mill Type, Pipe Coatings (Methods and Problems)" by Donald A. Golbey, Sales Engineer, The Cleanola Co., Glenshaw, Pa.

2:00 pm—MECHANICAL SESSION—Club Room B

Chairmen: L. S. Mobley, Chief Engineer, Republic Steel Corp., Gadsden, Ala.
Robert J. Simes, Superintendent, Mechanical Dept., Lukens Steel Co., Coatesville, Pa.

"The Heating and Ventilating of a Modern Steel Mill Building" by Charles H. Smith, Consultant and formerly Vice President, L. J. Wing Mfg. Co., Div. of Aero Supply Mfg. Co., Inc., Linden, N. J.

"Gas Fired, Radiant Comfort Heating" by J. N. Evans, Superintendent, Fuels and Power, and V. J. Urschel, Heating and Ventilating Engineer, Lorain Works, National Tube Div., United States Steel Corp., Lorain, Ohio.

"The Influence of Preloading by Sand Dunes on Economy of Foundations at the New Midwest Steel Mill" by Elio D'Appolonia, President, E. D'Appolonia Associates, Pittsburgh, Pa., and L. A. Fugassi, Chief Engineer, Midwest Steel Corp., Div. of National Steel Corp., Valparaiso, Ind.

Wednesday, September 28

9:00 am—ELECTRICAL SESSION—Club Room B

Chairmen: J. F. Kostelac, Assistant Electrical Superintendent, Midland Works, Crucible Steel Co. of America, Midland, Pa.
Clayton L. Squier, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

"A Training Program for Key Electrical Maintenance Employees" by Dr. Joseph S. Kopas, Training Counselor, Republic Steel Corp., and Director, Human Engineering Institute, Cleveland, Ohio.

"Maintenance of Electric Power Equipment" by John G. Roberts, Power Foreman, Bethlehem Steel Co., Lackawanna, N. Y.

"Safety for Steel Plant Electrical Men" by J. F. Trenner, Assistant Superintendent Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

9:00 am—OPERATING PRACTICE SESSION—Ballroom

Chairmen: W. A. Black, Assistant Director of Research, Republic Steel Corp., Cleveland, Ohio.
R. W. Holman, Division Chief Engineer, Tennessee Coal & Iron Div., United States Steel Corp., Fairfield, Ala.

"Fundamentals of Heat Distribution and Refractory Wear in Electric Steel Furnaces" by W. E. Schwabe, Product and Process Development Laboratory, National Carbon Co., Div. of Union Carbide Corp., Niagara Falls, N. Y.

"Production Aspects of the Dwight-Lloyd McWane Ironmaking Process" by H. E. Rowen, Vice President, Dwight-Lloyd, and C. D. Thompson, Assistant to Director of Research, McDowell Co., Inc., Cleveland, Ohio.

"Use of the Open Coil Process to Change Composition and Produce Improved Sheet Steels" by John A. Bauscher, Vice President—Research, Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

2:00 pm—COMBUSTION SESSION—Ballroom

Chairmen: Arthur S. Merrow, Assistant Fuel Engineer, Bethlehem Steel Co., Lackawanna, N. Y.
F. S. Swaney, Chief Combustion Engineer, Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Elimination of a Coke Plant Relief Holder" by H. E. Taylor, Superintendent, Coke & Chemical Div., Alan Wood Steel Co., Conshohocken, Pa.

"Oxygen Steelmaking in the Ajax Furnace at the Appleby-Frodingham Steel Co." by Albert Jackson, Technical Director of Appleby-Frodingham Steel Co., Scunthorpe, and Technical Adviser on Steelmaking, United Steel Companies, Ltd., Sheffield, England.

"Oxy-Fuel Processes Increase Steelmaking Rates" by E. F. Kurzinski, Manager, and R. D. Jones, Development Engineer, Applied Research and Development Div., Air Products, Inc., Allentown, Pa.

Exposition and Technical Sessions are at Cleveland Public Auditorium

2:00 pm—ROLLING MILL SESSION—Club Room B

Chairmen: F. G. Kredel, Chairman Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio.
R. C. Schaefer, Assistant Superintendent, Hot Strip, Soaking Pit and Blooming Mill Dept., Steubenville Works, Wheeling Steel Corp., Steubenville, Ohio.

"Analytical Investigation of the Cold Rolling of Bar Stock" by Dr. Alvin S. Weinstein, Assistant Professor of Mechanical Engineering, Dr. Carl F. Zorowski, Assistant Professor of Mechanical Engineering, and Frank J. Loss, Research Assistant, Carnegie Institute of Technology, Pittsburgh, Pa.

"New Automated Structural Rolling Facilities at South Works United States Steel Corp., Chicago, Illinois" by V. H. Lindberg, Superintendent, Structural Div., and J. E. Duffy, Works Chief Engineer, South Works, United States Steel Corp., Chicago, Ill.

"Ceco's Ochiltree Works Modern Electric Furnace Bar and Merchant Mill" by W. B. Jacobsen, Works Manager, Ochiltree Works, Ceco Steel Products Corp., Lemont, Ill., and Lawrence S. Barker, Jr., Project Manager, The Rust Engineering Co., Birmingham, Ala.

6:00 pm—OLD TIMERS' DINNER—Euclid Ballroom

Thursday, September 29

9:00 am—ELECTRICAL SESSION—Ballroom

Chairmen: H. W. Dorset, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.
J. A. Bruce Pinney, Assistant Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

"Electrochemistry in the Steel Industry" by E. E. Vonada, Product and Application Specialist, Reliance Electric and Engineering Co., Cleveland, Ohio.

"New Concepts in Power Control Rooms for Steel Mill Drive Systems" by V. E. Verheyden, Design Engineer, Industry Control Dept., General Electric Co., Roanoke, Va., and D. C. Nelson, Plant Electrical Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.

"Static Power Supplies for Ore Agglomeration" by M. F. Corcoran, Application Engineer, Industrial Systems Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: William M. Bloom, Senior Fuel Engineer, General Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
Charles W. Dunn, Superintendent—Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"5-Zone Reheat Furnace—South Works" by George H. Krapf, Division Superintendent, Power Production, South Works, United States Steel Corp., Chicago, Ill.

"New Approach to Centralized Utility Dispatching at Fairless Works" by F. W. Allen, General Foreman Utilities Dispatching, and L. Cizmadia, Fuel Engineer, Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Waste Heat Boiler Applications at the Inland Steel Company" by W. M. Douglas, Assistant Superintendent (Power, Steam & Combustion Depts.), Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

2:00 pm—LUBRICATION SESSION—Club Room B

Chairmen: A. E. Cichelli, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.
Walter Mainwaring, Jr., Works Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"A Standardized Method For Rating Roller Bearing Load-Carrying Capacity" by E. C. Denné, Jr., Assistant Chief Engineer, SKF Industries, Inc., Philadelphia, Pa.

"Why Straight Cylindrical Bearings in the Steel Industry?" by Philip H. Hutchinson, Manager, Pittsburgh Zone, Hyatt Bearing Div., General Motors Corp., Pittsburgh, Pa.

"Life Dispersion of Anti-Friction Bearings" by L. E. Root, Senior Engineer, Rollway Bearing Co., Inc., Syracuse, N. Y.

2:00 pm—FOREIGN SESSION—Ballroom

Chairmen: Harry L. Jenter, Vice President—Operations, American Steel & Wire Div., United States Steel Corp., Cleveland, Ohio.
Emil Kern, Vice President—Engineering, Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

"Observations of the Steel Industry in India and Japan" by John L. Young, Vice President—Engineering Technology, United States Steel Corp., Pittsburgh, Pa.

"Steel Production in Latin American Countries" by Gen. Edmundo de Macedo Soares e Silva, Managing Director, Companhia Siderurgica Paulista—Cosipa, Sao Paulo, Brazil, and President, Latin American Institute for Iron and Steel, Santiago, Chile.

"Report on the Present Achievements and the Immediate Prospects of Development of Soviet Ferrous Metallurgy" by Ivan Denisenko, Economist, Economic Research Institute, and Roman Belan, Metallurgical Engineer, Head, Iron and Steel Industry Dept., State Planning Commission, USSR.

7:00 pm—FORMAL DINNER AND DANCE—Ballrooms

Speaker: Martin D. Hughes—Noted impersonator and humorist—alias Countess Pulaski.

10:00 pm—DANCE—Ballrooms

AISE members and guests. No admission charge.

Friday, September 30

9:00 am—ELECTRICAL SESSION—Ballroom

Chairmen: John A. Drgon, Division Superintendent, Maintenance and Utilities, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.
Richard G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Computers for Industrial Control" by R. W. Sonnenfeldt, Manager, Engineering, Industrial Computer Systems Dept., Radio Corp. of America, Natick, Mass.

"Analog and Digital Techniques Used in Rolling Mill Electrical Systems Design" by D. E. Abell, Supervisory Engineer, Systems Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

"Application of Digital Computers for Accounting and Control of Continuous Processing Lines" by R. W. Kirkland, Application Engineer, Metal Rolling and Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

9:00 am—OPERATING PRACTICE SESSION—Club Room B

Chairmen: William O. Bishop, Superintendent, Plant 2 Blast Furnaces, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.
Thomas L. Nabors, Chief Combustion Engineer, Southern District, Republic Steel Corp., Gadsden, Ala.

"Pressure Drop Regulation Closes The Blast Furnace Control Loop" by Otto J. Leone, Consulting Engineer, West Newton, Pa.

"Limitations of Blast Furnace Stoves" by T. R. Schuerger, Supervising Technologist, and Dr. J. C. Agarwal, Research Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

"The Use of Natural Gas in Blast Furnaces at the Pueblo Plant of the CF&I Corp." by John M. Negomir, Practiceman, Blast Furnace Dept., Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

2:00 pm—OPERATING PRACTICE SESSION—Ballroom

Chairmen: F. F. Argust, Superintendent, Industrial Engineering, Pueblo Plant; The Colorado Fuel and Iron Corp., Pueblo, Colo.
Clyde A. Roberts, Jr., Chief Engineer, Phoenix Steel Corp., Phoenixville, Pa.

"The Next Step in Steel Plant Data Processing" by W. N. Spray, Manager, Methods & Procedures, Production Planning Div., United States Steel Corp., Pittsburgh, Pa.

"Minimizing Pollution from Pickling Lines: Automatic Control of Strip Pickling Bath Composition" by C. W. Shingledecker, Research Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Steps Toward Coke Plant Automation" by N. F. Agnew, Vice President, Femco, Inc., Irwin, Pa.

. . . . . **Social Functions are at The Statler Hilton** . . .

LADIES PROGRAM

HEADQUARTERS

PARLOR E

THE STATLER HILTON

TUESDAY, September 27

9:00 am — Ladies Registration — Parlor E, The Statler Hilton
12:30 pm — Social Hour — Pine Room, The Statler Hilton
1:15 pm — Luncheon — Euclid Ballroom, The Statler Hilton

WEDNESDAY, September 28

12:00 noon — Luncheon — Higbee's Lounge
The Higbee Co. is located on Public Square

THURSDAY, September 29

9:30 to 11:30 am — Kaffee Klatsch — Parlor E, The Statler Hilton
7:00 pm — Formal Dinner — Ballrooms, The Statler Hilton
10:00 pm — Dance — Euclid Ballroom, The Statler Hilton

★ ★ ★

Honorary Chairman — Mrs. S. C. Read
Honorary Vice Chairman — Mrs. W. J. Schuster

General Chairman — Mrs. M. L. Damm
Vice Chairman—Mrs. W. P. Smith

★

To partially cover the cost of ladies' activities, a flat charge of $5.00 will be made, covering everything except the formal dinner. This must be paid on registering, when tickets will be issued for the various events.

HOTEL RESERVATIONS

Arrangements have been made with the various hotels in Cleveland, whereby they have set aside blocks of rooms for the use of those attending the convention and exposition of the Association of Iron and Steel Engineers, September 27, 28, 29 and 30.

We suggest that you make your reservation as early as possible, directly to the hotel of your choice. If that hotel cannot take care of you, they will pass your reservation on to the Cleveland Convention Bureau for placement elsewhere. Specify the type of accommodations desired and the time of your arrival. Be sure to state that your reservation is for the AISE convention.

1960 IRON and STEEL EXPOSITION

CLEVELAND

September 27, 28, 29, 30

LIST OF EXHIBITORS

A

Acme Steel Co., Fabricated Materials Div. & Acme Steel Products Div.
The Adalet Manufacturing Co.
Ajax Flexible Coupling Co., Inc.
Alemite Div., Stewart-Warner Corp.
Allen-Bradley Co.
The Alliance Machine Co.
The Louis Allis Co.
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B

Bailey Meter Co.
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C

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Cutler-Hammer, Inc.

D

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DEMAG Aktiengesellschaft
Designers for Industry, Inc.
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E

Eaton Manufacturing Co., Cleveland Worm & Gear Div., Farval Div. & Dynamatic Div.
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F

Fabreeka Products Co.
Farval Div., Eaton Mfg. Co.
Federal-Mogul Service Div., Federal-Mogul-Bower Bearings, Inc.
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G

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GPE Controls, Inc.
Gregory Industries, Inc.
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H

Hagan Chemicals & Controls, Inc.
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Harnischfeger Corp.
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I

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Industrial Nucleonics Corp.
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K

Kane & Roach, Inc.
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LIST OF EXHIBITORS (continued)

L

LaDeau Manufacturing Co.
Lake Shore Electric Corp.
Larco, Inc.
Leeds & Northrup Co.
LeRoi Div., Westinghouse Air Brake Co.
Linde Co., Div. Union Carbide Corp.
Link-Belt Co.
Liquid Carbonics Div., General Dynamics Corp.
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Loftus Engineering Corp.
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M

Magnaflux Corp.
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McGraw-Edison Co., Pennsylvania Transformer Div.
Mesta Machine Co.
Mine Safety Appliances Co.
Minneapolis-Honeywell Regulator Co.
Mobil Oil Co., Div. of Socony Mobil Oil Co., Inc.
Morgan Construction Co.
The Morgan Engineering Co.

N

National Carbon Co., Div. Union Carbide Corp.
National Electric Coil Div., McGraw-Edison Co.
Nife Incorporated, Nickel Cadmium Battery Div.
Nife Incorporated, Lorica Battery Div.
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O

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P

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Pennsylvania Transformer Div., McGraw-Edison Co.
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Pick Manufacturing Co.
Poole Foundry & Machine Co.
H. K. Porter, Inc.
H. K. Porter Co., Inc., Delta-Star Electric Div.
The Post-Glover Electric Co.
The Pyle-National Co.

R

Radiant Lamp Corp.
Radio Corp. of America
The Ramtite Co.
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Geo. P. Reintjes Co.
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Republic Flow Meters Co.
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Research-Cottrell, Inc.
Ringsdorff Carbon Corp.
Robinson Ventilating Co.
Rockbestos Wire & Cable Co., Div. of Cerro de Pasco Corp.
Rollway Bearing Corp.
Rust-Oleum Corp.

S

Selas Corp. of America
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Silent Hoist & Crane Co.
Simplex Wire & Cable Co.
SKF Industries, Inc.
Socony Mobil Oil Co., Inc., Mobil Oil Co. Div.
Spero Electric Corp.
Spraying Systems Co.
Square D Co.
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Stewart-Warner Corp., Alemite Div.
Sutton Engineering Co.
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T

Taylor Instrument Companies
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The Torrington Co., Bantam Bearings Div.
Trabon Engineering Corp.
Twin Disc Clutch Co.

U

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W

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Yale & Towne Mfg. Co., Yale Materials Handling Div.
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IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

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A Fully Continuous Narrow-Strip and Wire-Rod Mill

by LUDWIG WEGMANN, DEMAG, Duisburg, Germany

*American operators will be interested in the details of the fully continuous narrow strip and rod mill installed at the Belval Division of ARBED in Esch-Luxemburg.**

THE planning of the new continuous narrow-strip and wire-rod mill for ARBED was based on the following rolling programme:

1. Narrow steel strip from 0.39 to 2.76 in. wide and 0.031 to 0.197 in. thick.
2. Wire rod from 0.197 to 0.47 in. in diameter in coil weights of 660 lb.

The mill had to be planned to roll 38 net tons of narrow strip and about 22 tons of wire rod an hour. All finished rolled sections were to be rolled down from billets 2.59 × 2.59 in. and 30 ft long.

After careful consideration the layout shown in Figure 1, in diagrammatic form, was decided upon. Main items of the plant are the billet reheating furnace, three continuous groups of roughing stands, two continuous lines of finishing stands and the reeling and handling equipment set up behind the plant. Altogether, there are 35 stands, including those with vertical and edging rolls.

Strip up to 1.38 in. wide is sent down two rolling lines, while that up to 2.76 in. wide is processed in a single rolling line. All thicknesses of wire rod are processed in two rolling lines.

Except in the case of some of the last stands of the two continuous lines of finishing stands, the same roll passes are used for rolling narrow strip and rod, so that a minimum of time is lost in converting the mill to roll strip or rod. As each stand is separately driven, the necessary speed of the rolls in each stand for a given operation can also be set easily.

A special row of passes in the middle of the roll barrels is used for strip from 1.38 to 2.76 in. wide. As mentioned above, these sizes of strip are processed in a single rolling line and, as they are the ones which are most difficult to divert laterally, one of the lines of finishing stands was set up in a dead straight line with the roughing stands to ensure that the wider sizes of strip can be processed without being diverted.

All types of strip exit from stand 23 or 23a with a maximum speed of 3300 fpm while stand 22 or 22a is the finishing stand for 0.197 in. rod, which exits at a maximum speed of 4380 fpm. The plant can thus be called a multi-purpose mill, offering the operational advantage that it can be used either as a fully continuous strip mill or as a fully continuous wire-rod mill.

* Abstracted from Demag News, No. 148, 1957.

BILLET REHEATING FURNACE AND AUXILIARY EQUIPMENT

The 2.59 × 2.59 in. and 30 ft long cleaned billets are laid out on a billet table in a bay at right angles to the main mill bay. A motor-roller table then transfers them to the reheating furnace, into the side of which they are pushed by an electric billet pusher car. A pusher at the end of the furnace pushes the billets slowly through from one end of the furnace to the other, during which process they are warmed through to 1200 C. A pushout then pushes the billets far enough out of the furnace for them to be caught up by withdrawing rolls which complete the process and convey them on to the adjacent roller table. The billet reheating furnace can cope with 38 net tons an hour of cold charge, and is fired with blast furnace gas with a net calorific value of 110 Btu per cu ft. Approximately 1,480,000 Btu of gas heat are used per ton of charge for the above-mentioned output, gas and air being preheated in recuperators. Heating is done solely by nine end burners, any three of which can be regulated by flap valves. The sloping heating zone of the hearth has water-cooled square skids and the soaking zone of the hearth is of plastic chrome-magnesite compound.

As, in practice, it is not possible to use a whole 2.59 × 2.59 in. and 30 ft long billet weighing 660 lb for all widths of strip between 0.39 in. and 2.76 in., the billets are cut up to a convenient size for the width of strip to be rolled. If strip with a width of 2.76 in. is to be rolled, for example, a whole billet can be taken as initial material, and a coil with a weight of approx. 660 lb is produced. If, on the other hand, strip with a width of 0.39 in. is to be rolled, the maximum permissible weight of the coil is 83 lb, as the coils would otherwise fall apart when they were transported away. Therefore, the following cuts and coil weights were planned for the billets:

Width of strip 2.76–1.97 in., no cut, 660 lb
1.97–1.38 in., one cut, 330 lb.
1.38–0.79 in., two cuts, 220 lb
0.79–0.39 in., three cuts, 165 lb

For strip widths between 0.79 and 0.39 in. the rolled strip is cut once again by the shears in front of the strip coilers to give a coil weight of 83 lb for these sizes of strip.

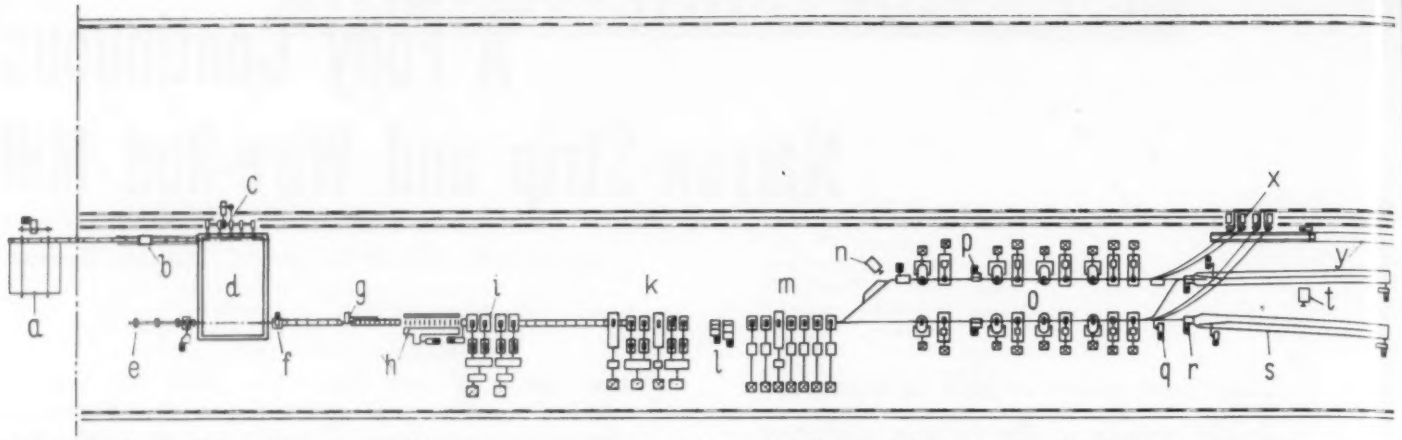


Figure 1 — Over-all layout of the continuous narrow-strip and wire-rod mill: a—billet table, b—billet pusher car, c—billet pusher, d—billet reheating furnace, e—pushout, f—withdrawing rolls, g—hot shear, h—heating tunnel, i—continuous roughing group (14.96 in.), k—continuous roughing group (13.38 in.), l—rotary cropping shears, m—continuous roughing group (12.59 in.), n—scrap reel, o—continuous wire-rod and strip finishing line, p—rotary cropping shear, q—switch, r—wobbler, s—apron conveyor, t—scrap reel, u—coilers, v—coil conveyor, w—coil holders, x—rod reeling machines, y—coil conveyor, and z—hook conveyor.

An electric up-cut shear cuts the billets and a gage behind the shear, at the side of the roller table, is used to set the exact length of the cut sections of the billets. An electrically operated switch then channels the cut lengths into the appropriate line along which they must pass in the heating tunnel to pass through the correct line of passes in the mill.

The heating tunnel is used to keep the billets at the correct temperature for exact tolerances right along the rolling lines, and electric rollers are used to travel the billets through the tunnel. The rollers themselves have high-grade casings able to withstand a temperature of 1200 C., with grooves matching the roll passes. No water-cooling was used on principle, for these rollers, as cold spots would develop on the billets resting on them if the rollers were stopped. Such cold spots would be detrimental during the rolling process. The driving parts and frame for the roller table are outside the heating tunnel.

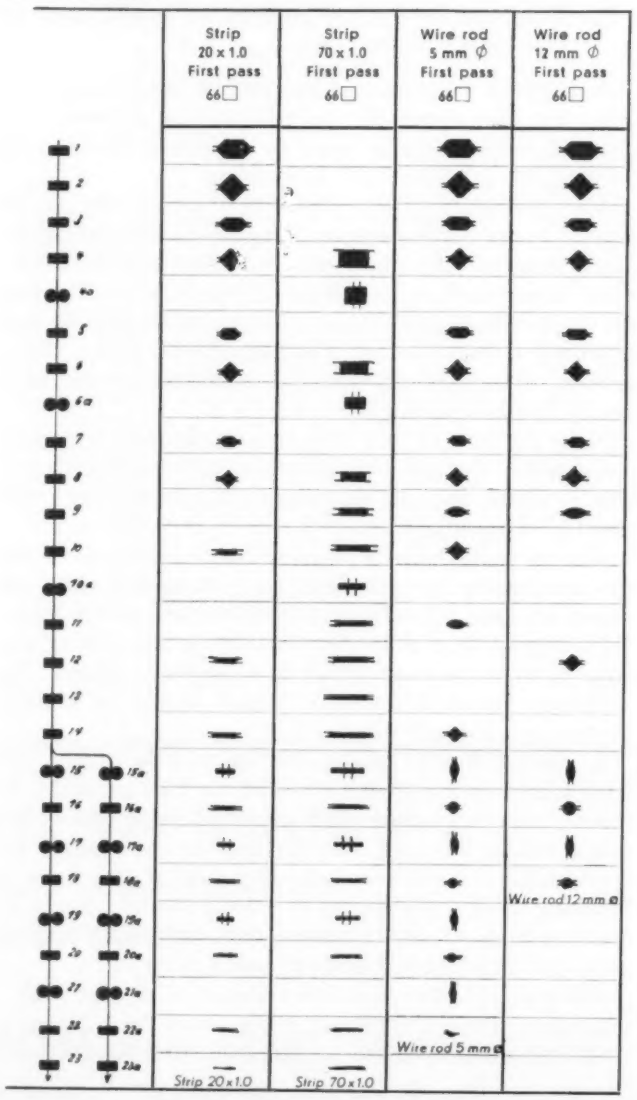
At the end of the heating tunnel there are individually controlled, raisable and sinkable stops for each of the three tunnel lines, so that the cut-up lengths of billet in the tunnel can be rolled separately and kept apart. The individual lengths can thus be sent consecutively, in a predetermined sequence, to the appropriate pass line of the first continuous group of roughing stands.

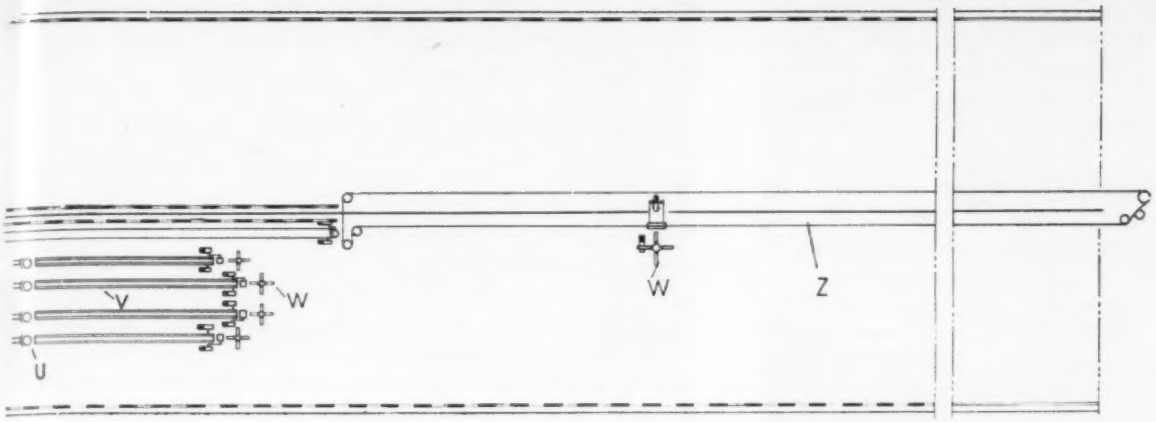
ROLLING THE BILLETS

The billets go through the mill in a predetermined sequence, and the switch in front of the heating tunnel is used to send the stock down the right pass line, of which the available number (one or two) depends on the finished cross section to be rolled. See Table I and Figures 1 and 2.

The arrangement of the groups of stands and their drives was chosen with a view to making them adaptable to the finished cross sections to be rolled. There are four stands in both the first and second groups of roughing stands, the stands being driven in pairs by separate motors. The second group also includes two separately driven edging stands for flat stock. The third group comprises six horizontal and one edging stand, all separately driven by motors with such a large range of speed control (1:10) that the speeds of the individual pairs of rolls can be adapted for any cross section, while the throughput of each stand can be kept virtually constant.

Figure 2 — Stock goes down one of two pass lines after No. 14 stand, depending on whether product is wire rod or flat. Units are mm.


Strip 20 x 1.0 First pass 66□
Strip 70 x 1.0 First pass 66□
Wire rod 5 mm ⌀ First pass 66□
Wire rod 12 mm ⌀ First pass 66□
Wire rod 12 mm ⌀
Wire rod 5 mm ⌀
Strip 20 x 1.0
Strip 70 x 1.0



Stands 1–14, including the edging stands, roll down the billet/bar stock under slight tension, which can be kept to a permissible minimum as a result of the separate driving motors. The stock leaving the fourteenth stand on its way to the finishing lines is thus extremely true to gage—an important factor for close tolerances in the finished product.

Stock leaving the fourteenth stand is rolled down further in the two lines of finishing stands, each of which comprises nine stands, alternately vertical and horizontal down to the ninth stand (the twenty-third if the stands are numbered consecutively from the beginning), the last stand also being a horizontal one. The twenty-third stand is used only for rolling strip, while wire rod exits from the twenty-second stand and stand No. 23 is not used.

No. 16 and 16a horizontal stands, and all vertical stands, No. 15, 17, 19 and 21, are two-high, whereas stands No. 18, 20, 22 and 23 are designed for operation as two-high or three-high units, depending on whether strip or rod is rolled. The mill motors always deliver their torque to the lower rolls, while the upper rolls are always driven by smaller, separate motors whose main task is to keep the rolls at the right speed. These latter motors therefore do no rolling work and are even entrained by the mill motor while stock passes through the stand. The stands are used exclusively as two-high stands for rolling wire rod, while the three-high arrangements, for which data is shown in Table II, is adopted for strip. The strip is then sent between the thick lower and the thinner center roll, while the upper thick roll backs up the center roll.

TABLE I
Details of the 35 Mill Stands

Stand no. and alinement	Motor details				Stand details			Strip speed, fpm
	Kw output	Rpm	Speed range	Gear ratio	Roll, rpm	Roll diam, in.	Barrel length, in.	
No. 1, Horizontal	300	80-240-600	1:7.5	1:30	2.67–20	14.96	33.46	10–75
No. 2, Horizontal	300	80-240-600	1:7.5	1:23.75	3.37–25.28	14.96	33.46	12.6–95
No. 3, Horizontal	300	80-240-600	1:7.5	1:17.4	4.6–34.5	14.96	33.46	17.3–129
No. 4, Horizontal	300	80-240-600	1:7.5	1:12.5	6.4–48	14.96	33.46	24–179
No. 4a, Vertical	75	60-240-600	1:7.5	1:10.67	7.5–56.25	21.65	8.07	40.7–307
No. 5, Horizontal	300	80-240-600	1:7.5	1:7.904	10.12–75.9	13.38	31.49	34.1–256
No. 6, Horizontal	300	80-240-600	1:7.5	1:5.524	14.48–108.62	13.38	31.49	49–380
No. 6a, Vertical	75	80-240-600	1:7.5	1:10.67	7.5–56.25	21.65	8.07	40.7–307
No. 7, Horizontal	300	80-240-600	1:7.5	1:3.948	20.26–152	13.38	31.49	71–530
No. 8, Horizontal	300	80-240-600	1:7.5	1:2.718	29.43–220.75	13.38	31.49	103–770
No. 9, Horizontal	200	200-400-1000	1:5	1:4.255	47–235	12.59	29.52	154–770
No. 10, Horizontal	200	200-400-1000	1:5	1:4.255	47–235	12.59	29.52	154–770
No. 10a, Vertical	75	80-240-600	1:7.5	1:4.8	16.7–125	21.65	8.07	91–682
No. 11, Horizontal	200	200-400-1000	1:5	1:3.08	65–325	12.59	29.52	214–1060
No. 12, Horizontal	200	200-400-1000	1:5	1:3.08	65–325	12.59	29.52	214–1060
No. 13, Horizontal	200	200-400-1000	1:5	1:2.36	85–425	12.59	29.52	279–1400
No. 14, Horizontal	200	200-400-1000	1:5	1:2.36	85–425	12.59	29.52	279–1400
No. 15, No. 15a, Vertical	120	300-600-1500	1:5	1:2.965	101.2–506	11.81	18.89	310–1510
No. 16, No. 16a, Horizontal	200	120-240-600	1:5	...	120–600	11.81	18.89	370–1850
No. 17, No. 17a, Vertical	120	300-600-1500	1:5	1:2.118	141.7–708.5	11.81	18.89	422–2100
No. 18, No. 18a, Horizontal	200	160-320-800	1:5	...	160–800	11.81	17.71	492.2480
No. 19, No. 19a, Vertical	120	300-600-1500	1:5	1:1.385	216.5–1082	11.81	18.89	620–3220
No. 20, No. 20a, Horizontal	200	225-450-1200	1:5.33	...	225–1200	11.81	17.71	694–3700
No. 21, No. 21a, Vertical	120	300-600-1500	1:5	1:1.022	233.5–1467	11.81	18.89	695–4350
No. 22, No. 22a, Horizontal	200	300-600-1500	1:5	...	300–1500	11.81	17.71	925–4610
No. 23, No. 23a, Horizontal	200	225-450-1200	1:5.33	...	225–1200	13.38 6.90 13.38	17.71	785–4180

Whereas the different lines of stock are rolled under slight tension in the three groups of roughing stands and each stand has a different throughput, the bar stock between the third roughing group and the two continuous lines of finishing stands, as well as between the stands of the finishing lines, is rolled at a particular pressure, i.e., loops are formed in the stock in this part of the mill to guarantee that it is not rolled under tension and that the mill operators have a good means of checking the exact tolerances of the cross sections.

Both upward and downward loops are formed in strip, while wire rod is looped in the horizontal plane, both looping methods being determined by the cross section of the material. A more detailed account of the way in which the loops are formed is given later.

Rotary cropping shears are indispensable if rolling operations are to proceed smoothly. These have been set up between the second and third groups of roughing stands and in front of stands No. 17 and 17a in the finishing lines. Their essential function is to crop the bad, usually splayed, ends of the bar stock after a certain number of passes and while it is on the move.

The twisting of the bar stock within the mill is another important factor for perfect rolling. Twist rolls are incorporated in the three all-horizontal groups of roughing stands and have proved very satisfactory, particularly as far as their wearing qualities are concerned.

PRODUCT DISPOSITION

The flat strip leaving the lines of finishing stands is turned up on edge by twist guides and sent through pinch rolls which discharge it at mill speed on to apron conveyors via wobblers used to cause it to settle in a series of loops. The strip is then coiled on to pin-type underfloor coilers which are sunk to allow push-offs to transfer the coils on to conveyors. At the other end of the last-mentioned conveyors the coils are tied; suitable lifting equipment is available to make the coils easier to handle during this operation. The tied coils pass on singly to a transfer device which transfers them to a rotating four-arm coil holder, where they are picked up and carried away by lift trucks designed for the purpose.

Tube-like pipe guides are provided for conducting the rod to the reeling machines, and two horizontal coil conveyors, on which the coils are laid flat, take over the reeled coils and convey them to a transfer pocket at the end of the second conveyor, where they are taken over by the hook conveyor and transported to the rod storage. The horizontal conveyors are designed long enough for the coiled rods to be transferred to the hooks at a temperature which prevents the coils from sagging and becoming oval. For the sake of clarity, characteristic data such as roll diameters, speeds, motor outputs and transmission ratios are given in Table I.

TABLE II
Data on Stands Convertible to Three-High Operation

Stand No.	Three-high roll diam, in.	Strip speed, fpm
No. 18	13.38-6.90-13.38	560–2790
No. 18a	13.38-6.90-13.38	560–2790
No. 20	13.38-6.90-13.38	785–4180
No. 20a	13.38-6.90-13.38	785–4180
No. 22	13.38-6.90-13.38	925–4610
No. 22a	13.38-6.90-13.38	925–4610
No. 23	13.38-6.90-13.38	785–4180
No. 23a	13.38-6.90-13.38	785–4180

DESIGN INNOVATIONS AND SPECIAL FEATURES OF THE MILL EQUIPMENT

Horizontal stands—Bearings of the synthetic resin type are used for the rolls of stands No. 1–14; anti-friction bearings absorb the thrust. Stands No. 15–23 have anti-friction roll bearings throughout. The screw-down mechanisms for the upper rolls are all parallel hand-wheel units engineered to allow the screw on either side to be adjusted separately if necessary. The screws for adjusting the rolls laterally are moved from the front side of the stand, and chocks with clamp bars and clamps hold the rolls in the stand on this side. When the clamp bars are released and the clamps swung aside, the rolls and chocks are free to be removed.

To facilitate a quick change at any time to the reserve passes on the rolls without the guides between the stands being affected, the stands can be shifted, hydraulically or manually by means of screw rods, on a sliding-ways bed plate. Setting head, spindles and wedges incorporated in the housings and protected from dirt are used to release and anchor the stands to the bed plates quickly and effectively.

A noteworthy feature of the entering and delivery guides is that they can be swung aside by an air cylinder to free the windows of the housings completely when the rolls and chocks are to be removed, Figure 3.

Vertical stands—As can be seen from Figure 4 the vertical stands are special stands developed in the course of recent years, especially for continuous light-section, strip and wire-rod mills. The feature which determined the engineering conception for these stands was the overhead drive, the prime mover being set up on the mill floor. Quick roll- and stand-changing is essential in the case of mills with such high production rates. The driving gear set above the stand itself can thus be swung out through an angle of 90 degrees, so that the stand is open during the roll changing operations. The stands can be adjusted in the vertical plane—hydraulically in the case of the mill under discussion—so that each pass on the vertical rolls can be maneuvered into the rolling line.

When the rolls have to be changed, the whole stand is first raised and the spindles are thus pushed up into the bored-out pinions and secured in this position by a holding mechanism. The bolts in the universal couplings are then turned through 90 degrees and the stand is lowered. The overhead driving set is then swung around a cylindrical column, so that a crane can simply lift out the rolls.

To simplify the roll-changing operations, a whole stand can be removed from the lines and exchanged. Reserve stands must be readily available to speed the whole operation.

A further feature of interest is that the whole structure, including that for the driving set, is welded and that only the mill stand itself is of cast steel. Two years of operations have shown how worth-while this design is and how it is able to meet all requirements arising in modern rolling practice.

Drives and pinion gear sets—All main gears and pinion gear sets must be able to meet the most exacting

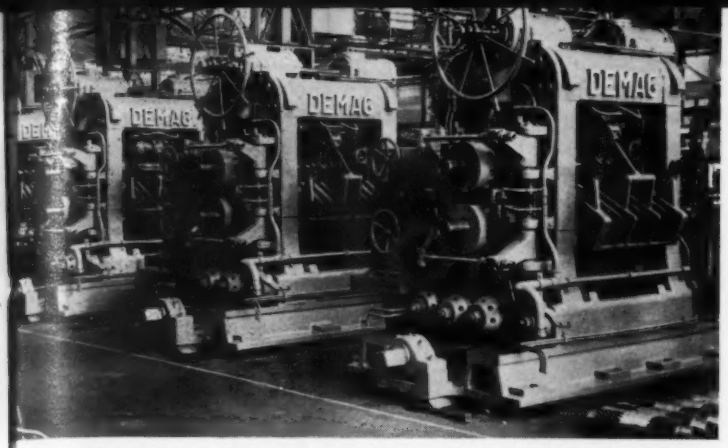


Figure 3 — Horizontal stands in the workshop. Note entry guides, screwdown mechanisms and the sliding way bed plates.

requirements if modern mills are to operate satisfactorily in continuous service. No breakdowns through wear or hot bearings must occur. A central-station oiling system with oil coolers and filters to maintain the right temperature and clean the oil is therefore indispensable.

Rotary shears—The rotary shears are electrically driven and always start from rest for every cut, which is initiated by the moving bar itself actuating a flap coupled to a switch or being seen by an electric "eye."

Apron conveyors with wobblers—Each line of strip delivered from the mill settles in a series of loops on an apron conveyor which delivers it to the coilers. The apron conveyors are of the endless-chain type, the chains on each side carrying a series of separate plates which bridge the gap between them and form a continuous, moving apron. An electric motor is used to drive such an apron conveyor through spur reduction gearing designed to give the conveyor a speed range of 17–50 in. per sec. A raisable slat is used to create a partition centrally down each apron conveyor, so that the strip coming from the mill can be channeled into two possible lines. In this way, the bars are not held up in the mill and production is not restricted severely by successive lengths of strip being delayed until the previous length has been coiled.

Strip coilers—The strip coilers can coil at a speed of 1560 to 2340 fpm hot strip leaving the mill. Such strip can be up to 2.76 in. wide and 0.22 in. thick. The coilers themselves are below floor level, only the pins on the vertical hollow driving shafts of the coiler driving head, the slightly raised coiler plates, wrapping and braking rolls, crop shears and push-offs being above floor level. The driving units for the coilers and the motors for the crop shears are also below floor level. Such a layout makes it easy for the operators to introduce the strip into the coilers and also to crop it, as the floor is clear of obstacles. Push-offs transfer the coiled strip to conveyors after the pins of the coiler plate have been withdrawn downwards. Various sizes of pin-type coiler plate can be fitted to cater for coils with the following diameters:

Internal 11.81, 19.68 and 23.62 in.
External 35.43, 40.55 and 42.54 in.

Conveyors and holders for the coils—An electrically driven coil conveyor of the endless-chain type serves each strip coiler. While on these conveyors the coils are

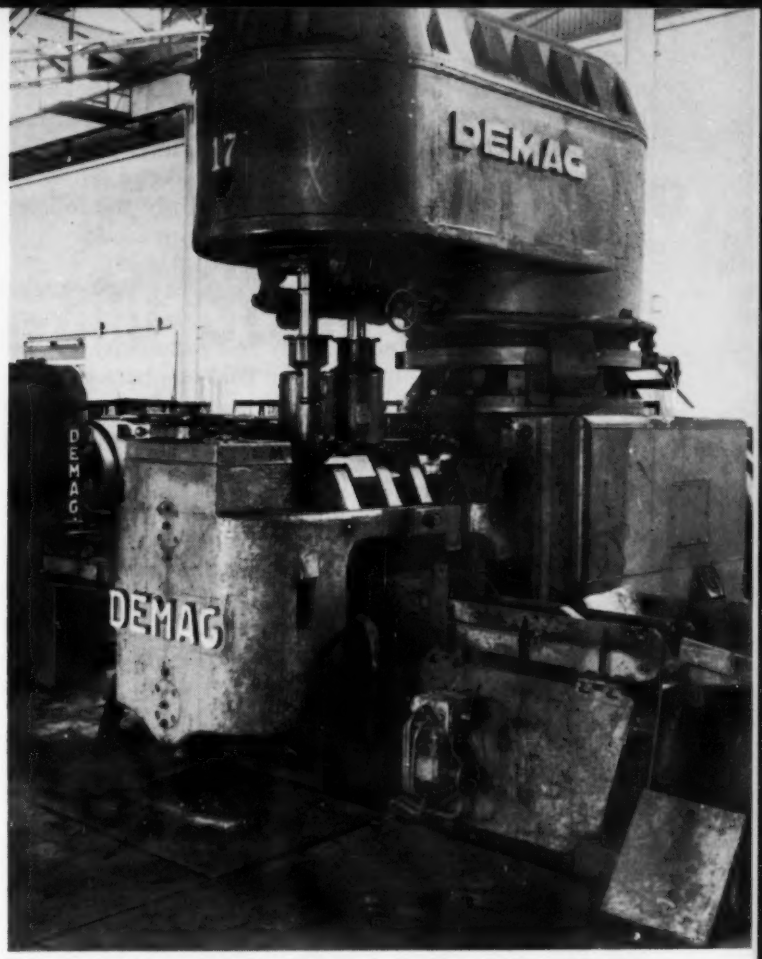


Figure 4 — The vertical roll stand overhead drive unit can be easily swung away to permit a quick roll change.

tied tightly for dispatch, and built-in coil elevators are available to make the coils easier to handle during this operation. At the end of the conveyors, the coils are tipped into pockets and then transferred to the rotating four-arm coil holders, which have arms split down the center and long enough to hold a number of coils. The width of the strip determines how many coils can be accommodated on an arm at any particular time. Special lift trucks are used to lift the coils from the arms of the holders and transfer them to the store.

Electrical—The exacting requirements the mill had to fulfill implied no-less-exacting requirements made on the electrical equipment. The latter requirements determined the drives and switching apparatus for the mill. The mechanical layout of the mill has its electrical counterpart, the roughing groups being fed by a bus system and the armature-fed motors of the two finishing lines being supplied individually. Auxiliary drives are both three-phase a-c and d-c.

All motors are self-ventilated motors with internal air flow. The row of transformers for the grid and the rectifiers is in a separate bay adjacent to the rolling mill bay, while the rectifier tanks are in another separate room. A further room on the same level as the rectifier room houses the rectifier controls, control panels for the motors, mimic switching diagram for all the mill equipment, fault reporting equipment and low-voltage distributing system in factory-assembled switch cabinets. The motors for the roughing groups are also in this latter room. The motors for the finishing lines are in the rolling mill bay itself.

Rectifiers and switching equipment—The roughing mill motors are fed by the rectifiers from the 5-kv bus system. Details of the high-tension switchgear are given later. The six-anode rectifier tanks have no pumping system and are air-cooled. For the sake of economy and to simplify the keeping of spares, only the following three types of rectifier tanks have been used:

One type for the bus-bar-fed armatures of the roughing group motors.
One type for the individually fed armatures of the finishing-line motors, for the field bus bars and the d-c auxiliary drives.
One type to feed the excitation fields for the motors of the third roughing group.

Except for the last-mentioned type of rectifier tank, which is in the rectifier cabinet with the switching apparatus and controls, all tanks stand free in a room used exclusively to house this equipment.

The transformers for the rectifiers are in the immediate vicinity of the tanks, each transformer being on the same level as the rectifier it serves. Pyranol transformers were chosen, as they involve no fire hazard and require little space. Installation costs were therefore low and no partition walls or oil quenching pits were required.

As mentioned above, the motors for the roughing groups are fed by a bus system with three separate sections corresponding to the layout of the mill. In view of the low rolling speed, about 690 fpm at stand 8, the first and second groups of roughing stands are regulated at constant voltage. Field regulators in the control pulpit are used to remote-control the motor speeds in the regulatable range. Speed control was chosen for the third roughing group, owing to the variation in rolling speed between 780 and 1560 fpm and the small distance between the stands. Nothing more is needed for speed control than two-anode rectifier tanks to vary the field.

All motors for the two finishing lines have individually fed armatures, as field regulation seems out of place for the control times resulting from the rolling speeds and spacings of the last stands. Each motor has its own rectifier. The operator at the control pulpit presets the desired speed necessary for the motor, while a tachometer directly coupled with the mill motor (mounted overhung) indicates the actual speed. The potential difference arising from the presetting instrument and the tachometer is used to regulate the armature voltage via a tubular regulator in such a way that the speed remains constant.

Whereas the roughing groups have no loopers, they are used in front of all finishing stands (horizontal and vertical) for rolling strip. The loopers are air operated and their deflecting angle automatically determines the speed of the motor for the next stands.

If rod is rolled, looping tables are substituted for the loopers used in strip rolling, the loops being formed in the horizontal plane. The size of the loop is measured without it being touched, and the speed of the motor for the next stands is automatically corrected with the help of a measuring amplifier. The capacitance problems involved in contact-free measurement were satisfactorily solved. Special measuring capacitors record the position of the stock, which always settles in the desired way on the measuring plate through the action of the loop bumpers with which the mill is equipped. These bumpers come into action when the stock enters the stand in front and return to their original position as soon as it has passed through. Photo-electric equipment of advanced design, specially developed for wire-rod, hoop and light-section mills, is used to record the passage of the front and back ends of the stock.

Ventilation equipment—Installed at the end of the motor room, the ventilation equipment comprises an independent system for the motor room, another for the rectifier room and two sets of fans for the finishing lines. The first two systems are provided to maintain a positive pressure in the motor and rectifier rooms and thus prevent the infiltration of dust. The motors themselves are cooled by three suction fans installed in the basement underneath the motor room. Each group of roughing stands has its own set of fans. If the outside temperature is low, the ventilation systems for the motor and rectifier rooms can be operated as pure recirculating systems.

High tension switchgear—The high-tension switchgear is housed in factory-assembled switch cabinets. Air-blast circuit breakers are used, which can be moved out of the cabinets. All the equipment requires a remarkably small amount of space. A distribution sub-system for the finishing line drives was installed underneath the room for the cabinets. In this case the switchgear consists solely of isolators in open boxes.

Auxiliary drives—Some of the auxiliary drives are fed with direct current some with three-phase alternating current. D-c motors were chosen where synchronization with a mill stand and the main drive for the strip mill was necessary, e.g., in the case of the heating tunnel and the withdrawing rolls behind it, the whole group being immediately in front of the roughing group stands. In the above instances, the motors are reversible and are fed from the 800-v bus bar for the first roughing group. The pinch rolls in front of the second finishing line, as well as the pinch rolls and wobblers behind both finishing lines, also have d-c drives. A simple solution was again found to the synchronization problem by deriving the voltage for these motors and the main mill motors with which they are synchronized from the same source. The cropping shears in the two finishing lines have d-c motors and their own rectifiers, this solution being adopted to meet the need for crop ends of uniform length, whatever the speed of the mill. The motors for the apron conveyors and under-floor coilers are also d-c motors, no synchronization being necessary here.

All roller conveyors, the transfer, the driving units around the furnace, hot shear and rotary cropping shears between the roughing groups, gages and switches, as well as the driving motors for equipment at the end of the mill—such as chain conveyors, up-enders, coil handling equipment, coiled-rod handling equipment and push-offs, as well as the four-arm coil holders—are equipped with three-phase a-c motors.

Mention must be made of the fact that the mill was planned to roll strip with a maximum width of 2.76 in., but that this limit has already been pushed up to 3.35 in. in the course of two years of operation—proof that the whole installation was engineered with sufficient reserve. ▲

American Iron and Steel Institute 68th General Meeting

. . . . to review the problems of iron and steel production, leading operators of the steel industry met in New York City on May 25th and 26, 1960, at the general meeting of the American Iron and Steel Institute . . . . among the meetings were two technical sessions, one on blast furnace practice and one on oxygen in steelmaking . . . . selections from the papers from these and the general session of particular interest are reprinted here . . . .

"THE SCHWAB MEMORIAL LECTURE"

By EARLE C. SMITH,*
Chief Metallurgist and Director of Research
Republic Steel Corp.
Cleveland, Ohio

THE invitation arrived at my office last December, a day or two before my return from a trip to the Far East.

The trip to the Far East included a look at three steel plants in India, and one in Japan. Discussions with operating men were extremely interesting.

The Tata plant at Jamshedpur in India is many years old. At present, it is being expanded. It has been, and will remain, the largest Indian steel plant for at least a few years.

At the town of Rourkela, about 300 miles west of Calcutta, the Germans have built a new plant for the Indian government. This plant is now producing steel made from its own pig iron. Time will be required to determine this plant's capabilities.

The most interesting plant is the one designed and built by the Russians at Bhilai, about 500 miles west of Calcutta. My principal reason for making the trip was to see what kind of plant the Russians would build in India.

What I saw did not diminish my respect for Russian steelmaking potential. The Bhilai plant was better designed for continued production than any steel plant I have seen in either the United States or Russia proper. By the time we visited there, it was already exceeding planned output of quality product. The Russian performance in construction was outstanding—so good, in fact, that they delivered the components for the plant, all meticulously numbered and identified, even before the foundations were completed.

This was an uncommon performance by uncommon men.

Uncommon, too, were the young Russian experts who were instructing Indian workmen, not through interpreters, but in their Hindu tongue.

And this is the theme of my sermon here today, if this series of random thoughts has a single theme—the serious problem we in the American steel industry face in seeing to it that men of uncommon brilliance, spirit and initiative do not pass us by.

Particularly interesting in my early days were some of the personnel policies of the United States Steel Corp. during its early days. When the corporation was formed, backing up each man in top supervision were three men preparing for the specific job. In addition, the policy provided for the selection and preparation of five younger men for future needs. In other words, behind each critical job holder were eight men in various stages of preparation. Where could we find such strength in depth today?

During the time that I have been in the steel industry, this pattern for developing an industrial organization has disappeared. It seems impractical to consider that

* Because of the death of Earle Smith on May 20, 1960, this lecture was read by Charles M. White, Chairman, Republic Steel Corp.

it can ever occur again, due to the tax laws and political climate we seem bound to endure.

What we need are men of genius whose mental capabilities and physical stamina exceed the usual product of our time. More critical than the machines are the brains of those who manage them—not the operators, in spite of their wonderful skill which has always been a source of amazement to me.

What this industry needs—in fact, must have—are people who can now make every new unit produce at least double the unit it replaces. And this will only permit existence. Taxes and the inflationary wage toll require this minimum to insure survival.

It is very doubtful that the training of the usual engineer will develop the ability needed to meet our problems and master them. It is questionable whether our industry can adapt the new discoveries by science or the lone inventor in time to rescue us from a fate similar to that of the British or French steel industries during the 1920's and 1930's. In the short span of my lifetime, the steel industries of Britain and France have been wrecked by tax policies and labor laws, as war wrecked the German steel industry.

To hope for political insight into our problems seems but wishful thinking.

Deepening my concern is what I believe to be continued prejudice against the achievement of technical and scientific eminence in the world of business. As far back as my graduate days, this trend was evident. It was fashionable to look upon what we might now call applied science as something unfit to be so much as even mentioned in our circles. A favored expression was: "We must not prostitute our science for the benefit of the bloodlesss corporations." I cannot reconcile this viewpoint with my ideas that Julian and Walter Kennedy were helping the world when they built a steel plant in China. I can recall years ago a missionary relative lecturing to me in a somewhat proud and superior tone that his work was benefiting the heathen in India. A summary of my ideas was a statement that certainly did not enhance my prestige. It was simply: "Make a ton of pig iron one dollar cheaper and you will benefit the heathen in India."

Some of us were concerned even then—as we are now—over what we consider to be false values established for measuring the worth of an exceptional and gifted man. In scientific affairs, prestige was based upon the number of published articles that appeared in certain records of the scientific groups. Experimenters, like Thomas Edison, were openly ridiculed and considered almost as parasites existing at the expense of the group who regularly made their scientific accomplishments known by publication. Shrewd scientists observing this trend encouraged the publication basis for prestige.

In basic research, applied science or technology, such a measure of prestige is still very much a factor. In a very recent meeting the statement was made: "This man has to spend so much of his time constructing the scientific equipment for his colleagues that he cannot write papers. It will be difficult to advance him because this has hurt his standing in scientific circles." Such superficial standards will not help us to maintain the vitality of our industry.

The uncommon men we need in our industry should possess a quality of deep, intuitive understanding that often defies detection by standardized intelligence tests and measuring tools. And today, more than ever before, they need an ability to communicate.

During my years as a trouble shooter and steel plant metallurgist, my most difficult problem has been communication. It has been especially difficult to create interest in a problem that has been obscure enough to require the intuitive approach to find an answer. In 1918, we had a sure cure for the very coarse structure frequently found in aviation engine forgings, yet we were unable to explain why it worked. In 1958, Mr. John V. Russell of Republic Steel's Chicago metallurgical group developed an explanation of the cause based on experiments performed by British casting men. Thus, it was 40 years before science verified a practice that we trouble shooters knew, through experience, would work.

During more than 40 years spent in applying science in this business of trouble shooting in the metal industry, there have been other experiences that helped me realize we live in a changing world. I have been involved in labor riots and picket line fighting more than once. I know from experience the ways of these men of "practical life."

Personal observations in Britian and France in 1936 furnished some positive indications of what too much power in the hands of those of the "practical life" could lead to. I encountered my first steel plant slowdown during the Popular Front days of Leon Blum in France.

During the last two years I have visited steel plants in Russia, England, Germany, India and Japan. This has permitted observations of some of the world steel industry. Discussions with men who have been in China, including at least one very competent engineer who had visited there in 1958 and 1959, add to my mental distress as to our affairs. We have work to do—time is not in our favor.

One line of observation made in all countries I have visited deserves consideration. It is this: No tax plan can be devised that will eliminate the value of education. To the individual who has a broad education, it is the one permanent value that can exist, even through the chaos of a revolution as violent as the one that occurred in Russia. This is the best reason we have to explain the effort a Russian student puts forth to get a degree. Education in Russia is the one asset that is wholly owned by an individual. It can be used—even displayed in a nation that severely limits personal possessions. It is a matter of real prestige.

We too must find some way to motivate our younger or even our middle-aged group to consider additional education. I do not mean training. We need men and women educated so that they are able to proceed beyond the areas where the trained man now does a satisfactory job.

As an industry, we must find new answers since our competition in unfriendly nations now equals us in most areas of technology. In a few places they are more capable, as in the construction and operation of the blast furnace, our basic production unit. Add to that the tremendous disparity in wage costs and the fact that very few foreign competitors operate under as unfavorable a tax climate as our industry, and our task assumes major dimensions.

There is another area that needs our attention. You may, if you wish, regard this as an occupational bias, but I believe that we have dragged our feet in our research efforts—particularly in basic research. We need to dig deeper—much deeper—into the nature of steel and steelmaking processes. An industry of our stature should not rely upon others for the development of better theories, better methods and better products.

At the same time, we should not neglect the findings of the great scientists and researchers in our universities. We must recognize that there is a type of man and genius that gravitates to our institutions of higher learning rather than industry. Their work can often times be extremely valuable to us. Too many times in my experience I have seen vital knowledge discovered in a university, buried in a desk drawer, because of our preoccupation with current production problems. This is a waste we can ill afford.

But our immediate urgent requirement is to know our existing equipment and what it is capable of producing. An event that occurred a few years ago illustrates this point. In October, 1957—two days before the first Sputnik rocketed into orbit—I toured our Chicago plant with Dr. Ivan P. Bardin, deputy director of the Soviet Academy of Science and a recognized authority on steelmaking. Dr. Bardin wanted specifically to see a large electric furnace in operation, but I took advantage of his visit to ask him for his estimate of what our Chicago blast furnace could produce going full tilt. He studied the furnace a bit, asked the usual blast furnace questions about blower capacity, kind of coke available and so forth, and then confidently said: "Seventy-five thousand tons in any cool-weather, 31-day month."

His response had the effect of a shock, since the best we were getting from the furnace was approximately 54,000 tons a month. When I told the plant managers what Dr. Bardin had said, they shook their heads in disbelief and felt he must either have been exaggerating for impression's sake, or else was overrated in his knowledge of furnaces. Nevertheless, they agreed to take some of his suggestions and go at the production of this furnace with renewed energy.

In the months that followed, I visited steel plants in Russia, England and Germany. Thus it was about a year later—upon my return from Europe—that I asked the Chicago people what kind of production they were getting from the furnace. "Not 75,000 tons a month," I was told.

"That isn't what I asked—what did you get?"

"Seventy-four thousand five hundred ninety-two tons in October," was the reply.

It is not only in the tons of product that we need to know our capabilities but also in the terms of our users' economic results. We must know that what we produce will move into the users' plants and result in smoother plant operations than imported products.

In about 1965, the work force available in the United States will increase sharply. These people will go to work, to school, serve in the military or be unemployed. The United States Department of Labor does not indicate that the new job hunters will land in the production industries. This seems to be a reasonable conclusion. Our industry must find a means of increasing both production and the whole level of quality without adding more than a few people. There are no good grounds to hope that we could expect lower production cost except by automation and control of quality. We have no monopoly on automation. The smooth operations at the Russian-built plant in Bhilai, India, and the experiments with automation in the Soviet Union's laboratories need careful evaluation.

Our nation and our industry have been very fortunate up to this time. Much of our good fortune has been based on ample reserves of excellent raw material. That our mechanical accomplishments were based largely on material resources is something we tend often to overlook. Failure of material resources can cause neglect of the mechanical arts as it did in China many years ago. We may be very close to that period of industrial affairs where utmost skill in materials management will be needed to support the exceptional mechanical arts that will be demanded by the automated industry of the future.

This is one area where we still hold a decided advantage. No foreign competitors have developed the counterparts of our teams of contact metallurgists and steel plant operators. There is no country in the rest of the world where the user co-operation is so much a part of the whole program.

The principle of basing our business on the production of material tailored for its end use is the best insurance for the American steel industry. It is an area of activity we can expand quickly. Shortening the time lag between the new idea, reduction to practice and delivery of satisfactory steel will strengthen our business relations.

Productive capacity increases that require new capital investment for additional output, must face the task of doubling production of better quality with no increase in manpower. If this new capital equipment is to function at rates that will justify the expenditure, we must educate a group of in-plant specialists. This group must be provided with an adequate staff of trained supervisors qualified and skilled to direct activities of the labor force. At best, the metallurgist will be but a small part of this affair. There are not—and there cannot be enough—trained metallurgists in the next dozen years to supply such a staff. Last year, throughout the entire country, only 717 men graduated with metallurgical degrees. This is scarcely enough to cover the attrition of just one company—U. S. Steel.

In appraising our prospects for attracting new human resources, we must remember that steel has no monopoly in the metal field, and actually does not offer a better future than the metal user. In fact, the users of metal can provide more agreeable working conditions than must be encountered on a blast furnace cast house floor or steel melting shop.

The average years of schooling of those employed in the professional and technical groups in 1959 was 16.2 years. This means a bare undergraduate training. That this group must be expanded at approximately twice the rate of any other class of employed people is indicated from the United States Department of Labor's reports. But even if we could increase our output of graduate engineers and technologists, we know that 16 years of schooling will produce only mediocre men.

We could not double our educational facilities of the conventional type in a period of 10 years and expect anything but chaos and mediocrity at all levels.

We are tending to overlook, or at least underestimate, one vital area of human resources. I refer to the growing number of young women joining the ranks of college graduates. My training at the graduate level involved mineralogy, metallography and gas chemistry. In all these fields women are completely qualified. In fact, during my lifetime there have been in the United States, England and Germany, women metallographists who, in my opinion, excelled the men in that activity. Our industry would do well to start an attractive program to move many of our laboratory activities into the hands of educated women. This would ease our immediate situation.

Wherever possible we should provide the necessary motivation to get our educated men into plant operations for the coming years and keep them there. If we continue to lose highly competent educated men, we will be operating the greatest capital establishment of the metal world with mediocre people.

"OPERATING EXPERIENCE WITH THE NUCLEAR RAY BLAST FURNACE STOCK GAGE"

By PAUL D. JOHNSON,
Blast Furnace Superintendent
Republic Steel Corp.
Chicago, Ill.

A NUCLEAR stock level gage, developed by Republic Steel Corp.'s research department, is in use at Republic's Chicago plant. This development demonstrates how modern nuclear techniques may help solve important blast furnace measuring problems, thereby paving the way for ultimate automatic control.

Two of the important factors of blast furnace operation which relate to stockline gaging are:

1. Gaging with safety—control of the gas problem.
2. Gaging for maximum production—maintenance of uniform stockline levels.

DEVELOPMENT OF THE NUCLEAR STOCKLINE GAGE

The basic principle of nuclear gaging for the blast furnace is illustrated in Figure 1. The essential components consist of radiaton source on one side of the furnace, and a radiation detector on the other side. The detector measures the radiation coming from the source. When stock inside the furnace obstructs the radiation beam, the detector signals are reduced. The changes in detector signals, therefore, provide a measure of stock level by means of signal lights and recording instruments.

Although the gaging principle has been known for many years, it was applied to blast furnaces only recently. One of the major obstacles to its use was the

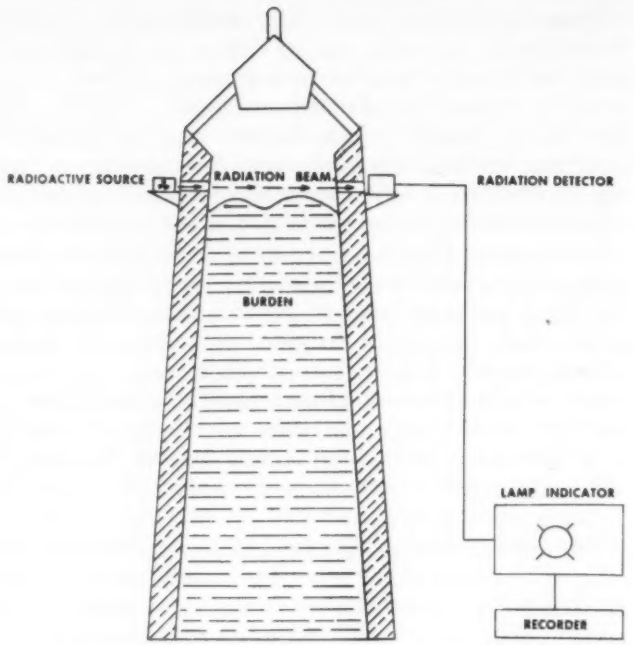


Figure 1 — A radiation beam is used for determining stock level.

size and construction of the furnace. The thick dense materials in the furnace lining absorb the radiation. An extremely powerful radiation source might be used to penetrate the lining, but its cost could be prohibitive. In addition to the high cost, tons of shielding would be required to protect workers from the incidental radiation. Because of these factors, the only practical solution appeared to be a system of radiation beam ports. These must be specially constructed furnace lining components, capable of transmitting radiation efficiently, without the risk of gas leakage or weakening of the furnace walls.

The investigation of these methods of nuclear stock level measurement was assigned to the nucleonics division of Republic's research department. Its work with blast furnace engineers led to the development of a system of radiation transmission ports for the blast furnace. Two basic types of beam ports were designed and installed in the Chicago furnace during its 1958 reline. One beam port design consists of steel tubes with welded plates at each end. These are used in the wear plate section of the furnace where lining erosion does not normally occur during a campaign. The other port design utilizes special blast furnace brick having longitudinal holes filled with dust-tight, gas-sealing devices. This type of port is installed wherever the furnace lining is not protected by wear plates. This beam port maintains its gas-tight properties and transmission efficiency, even though it wears away at substantially the same rate as the rest of the lining.

The design of this port system is a key factor in successful nuclear stockline gaging. The ports provide a relatively clear path for radiation through the furnace. Consequently, the strength of the sources can be low enough for safe, practical use. They can be housed in small, lead-lined containers, easily mounted on the side of the furnace. Each of these sources sends a beam through its corresponding port system to energize simple geiger tube detectors mounted on the opposite side of the furnace.

An over-all illustration of the nuclear gaging system developed by Republic's research department is seen in Figure 2. The system consists of four separate sources and detectors alined in the east-west direction, and three separate sources and detectors alined in the North-South direction. The specific gaging levels are as follows:

Distance from bell, ft	*Beam port direction*
6	East-West
7	North-South
8	East-West
9½	North-South
11	East-West
12½	North-South
14	East-West

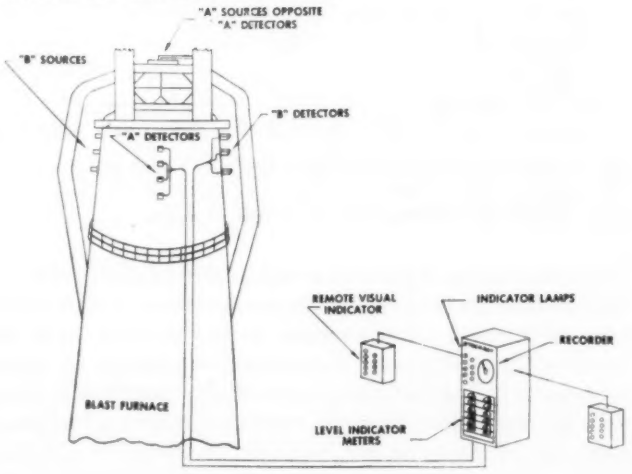
This arrangement was chosen to provide the required stock level information, as well as a measure of the stock contour or distribution.

The main control cabinet, is located in the furnace instrument room at floor level. Most of the electronic components are installed in this cabinet so that practically all maintenance can be performed in a safe area. The entire system can be tested from this control cabinet, thereby eliminating trips to the top of the furnace to check the detectors. Maintenance work at the furnace top is required only when tests at the control cabinet indicate that a detector is inoperative. Thus, the nuclear system transfers even the diagnostic maintenance procedures to a safe, gas-free location.

The stockline indicator lamps are located in the same relative positions as their corresponding detectors on the furnace. Whenever the stock moves below a given level, the corresponding signal lamp is energized. Each lamp remains lit as long as the stock is below its level. In addition, the East-West lamps are located in one vertical row, and the North-South lamps in an adjacent vertical row to provide stock distribution information, as well as stock level information. The recorder continuously shows the lowest stock position indicated by the lamp system.

The chart shown in Figure 3 is typical of the information provided by the nuclear system. Stock level variations, as well as bell dumping operations, are recorded to provide the same type of information as the conventional mechanical stockline recorders. It should be noted that the nuclear system continues to provide continuous stock level and distribution information, even while the recorder is recording the bell dumping operation.

Figure 2 — In gage system signals are transmitted to a convenient location for observation.



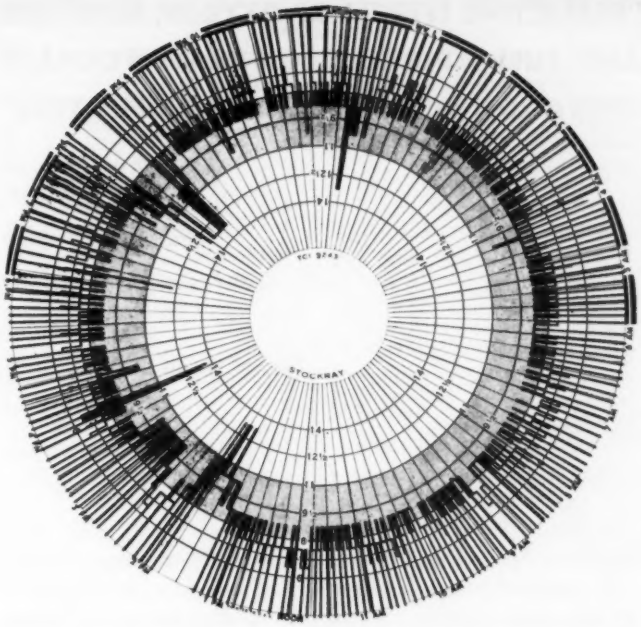


Figure 3 — Chart shows stock level variations as well as bell dumping operations.

PERFORMANCE EVALUATION

The use of nuclear gaging techniques for blast furnace stockline control has given the furnace operator a new degree of freedom. For the first time he can schedule stockline gage repairs on the basis of convenience rather than emergency. This has been demonstrated in over 18 months of continuous operation of the nuclear stockline gage. During this time, the nuclear system has never required a furnace shutdown for maintenance work.

In fact, in this period the furnace has been operated at record-breaking production levels. For example, the Chicago furnace produced an average of over 2450 tons per day for the first three months of 1960, even though the mechanical stockline gages were not used most of the time.

Since the nuclear system has been in service for only 18 months, it has not been evaluated over a complete furnace compaign. Until that has been done, the practice currently planned is to maintain the existing mechanical gage rods for possible future emergency use. This is necessary because of the possibility that extreme lining shifts may destroy the port alinement required for nuclear gaging. Until the nuclear system has proven its reliability through several campaigns, an enclosed mechanical stock rod should be provided as insurance.

On the basis of the production performance to date, nuclear stock level gaging appears to be a practical blast furnace tool. The main advantages are safer operations, reduced furnace downtime and reduced maintenance costs. In addition, the nuclear system points the way to automatic control possibilities for both stock level and distribution control.

"PREDICTING EFFECTS OF OXYGEN, MOISTURE AND FUEL ADDITIONS ON BLAST FURNACE OPERATION WITH ELECTRONIC COMPUTERS"

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THE desire to improve furnace performance and reduce costs coupled with the difficulty and expense of full-scale testing have led to numerous attempts to devise methods for predicting, quantitatively, the effects of making furnace changes.

Shortly after World War II, the investigation discussed in this report was initiated with three primary objectives:

1. To understand more clearly the technological aspects of the shaft furnace and to develop a dynamic mathematical method for predicting changes.
2. To show and evaluate quantitatively the important effects of interrelated operating variables (moisture, blast temperature, etc.) thus providing a means to optimize furnace performance.
3. To predict technical and economic advantages resulting from specific operational changes.

This paper is the first published on our work, and presents: (1) the essential elements of the method developed, (2) results of computed predictions for several iron furnaces and (3) a comparison of predicted with actual results.

The ability of operators to predict when, how and why a furnace may be going out of balance and their ability to make the proper corrections to keep the furnace in balance is undoubtedly the age-old reason why blast furnace operation has been considered an "art and not a science." Thus, in most instances, selection and regulation of any specific blast or burden variable will depend largely on a furnace operator's past experience.

CONTROL THROUGH USE OF A MATHEMATICAL MODEL

The basic consideration in this project was to study the interrelationship of thermal, chemical and mechanical processes in the blast furnace and how these processes were affected with operating changes. For example, some of the early work involved calculating all the effects resulting from changes in blast temperature and/or moisture additions. Later, the study involved effects related to oxygen enrichment, wind rate, burden composition, and fuel injection.

Early in these investigations, two important criteria were established; they serve as the fundamental basis for this work and may be stated as follows:

1. The blast furnace is an extremely complex thermochemical process operating in a relatively steady-state of balance, and any induced change will theoretically cause a change in every other dependent variable—chemically and physically.
2. Since the process consists of a series of many interrelated simultaneous reactions, it should be feasible to develop a dynamic model to define, measure, and analyze operational effects, when changing variables such as blast temperature, oxygen enrichment, fuel, and moisture additions. In addition, this model should also be useful in analyzing burden changes, furnace design parameters, effects of water cooling, etc.

Every effort was made to utilize actual blast furnace data as well as physical and chemical relationships to go beyond simple heat and material balances. All important kinetic and time relationships were incorporated and constantly tested for any new changes. Finally a model was developed which included such parameters as:

1. Complete heat and material balances.
2. Relative heat transfer in the shaft.
3. Direct versus indirect reduction.
4. Hydrogen reduction.
5. Shaft gas velocity.
6. Heat losses.
7. Wind rate.
8. Pressurization.

As now constituted, the model can be used for furnace control and for making predictions which have been confirmed in actual furnace operation with a high degree of accuracy. Operation of the model is based on subdividing the furnace into three parts, the utilization of a "standard case," and the application of an extremely complex trial-and-error method of calculation.

The following are three kinetic relationships used to compute: (1) heat transfer in the shaft and the top gas temperature, (2) the amount of carbon consumed in direct reduction or solution loss and (3) the amount of bosh gas hydrogen reacting in iron reduction.

(1) Heat transfer in shaft

$$[S_b(T - T_1) + (G_d - G_b)(t_x - T_1) + J] = \frac{(K\theta^{n\psi})}{(2.3G_b)}\left[\frac{(G_b - G_d)(t_x - T_1) + (G_b - S_b)(T - T_1) - J}{\log \dfrac{G_b(t_x - T_1)}{G_d(t_x - T_1) + (G_b - S_b)(T_1 - T) + J}}\right]$$

(2) Carbon for direct reduction $C = e + a \log \theta + f(z)$

(3) Hydrogen reduction $H = eh + f'(z)$

Table I includes a general nomenclature for the various algebraic terms employed. These equations indicate the general method of approach to the complex kinetic relationships involved. A complete discussion of these equations is beyond the scope of this paper but they will be treated in a more technical publication at a later date.

TABLE I
Nomenclature for Equations 1, 2, 3

S_b	= Weight of hot solids (x specific heat) entering smelting zone.
G_d	= Molar volume of gas (x specific heat) leaving heat exchange section.
G_b	= Molar volume of gas (x specific heat) entering heat exchange section.
J	= Function of thermochemical load and heat losses in heat exchange section.
T_1	= Temperature of solids entering heat exchange section.
T	= Temperature of solids leaving heat exchange section.
t_s	= Temperature of gases entering evaporator section.
K	= Empirical function of heat transfer coefficient between gases and solids in heat exchange section.
θ, ψ	= Functions of time and gas velocity, respectively in the heat exchange section.
C	= Carbon consumed in direct reduction of iron oxide.
h	= Total equivalent hydrogen at tuyeres.
c, a	= Empirical constants based on normal operating conditions.
f (z)	= Function of the total available carbon and hydrogen and physical properties of iron bearing materials.
H	= Hydrogen reacting with iron oxide.
e, n	= Empirical constants.
f′ (z)	= Function of total available carbon and hydrogen and physical properties of iron bearing materials.

THE "STANDARD CASE"

From the furnace operating data, a "Standard Case," or reference plane, is established to define the overall normal operating characteristics and permit mathematical solution of characteristic kinetic rate constants. Of course, the question often arises from operators as to the reliability of blast furnace operating data for making such a study. Accurate data are, indeed, always most desirable and, because of the great technical and economic value which can be derived, efforts should be made to make the most accurate measurements possible. However, operating a furnace and maintaining it in balance may not depend so much on the exact mass charge weights, blast variables, etc., if they are consistent, as on the incremental variations made. This would infer that a model based on any actual operating data should provide some valuable information since it will finally deal primarily with the incremental changes and effects.

At this point another question often arises which deserves comment: "Can furnace roughness or the ability of the furnace to accept certain changes be predicted—even though thermal balance is apparently maintained?" A simple answer to this question is, "No, not accurately at the present time." However, the model, with its resultant answers based on actual operating experience, can provide reasonable indications as illustrated and discussed later on. Moreover, results thus far have shed light on a number of interesting phenomena which are being closely studied and compared with actual furnace test results. These include: (1) furnace roughness, (2) lateral gas distribution, (3) heat transfer efficiency in the shaft, (4) carbon/hydrogen ratios in injected fuels, and (5) indirect reduction with variations in CO, CO_2, H_2, H_2O and N_2.

Incorporating the above and other kinetic relationships with complete heat and material balances into a dynamic model resulted in an extremely complex trial-and-error method of calculation. Hypothetical furnaces were eliminated early in this study except in special instances, because they did not represent actual variations found in furnace characteristics. For example, it has been found that important effects result from variations such as: (1) shaft height to volume ratio, (2) extent of water cooling in the shaft, (3) total heat losses and (4) type of burden and product. Therefore, analyzing a specific furnace for the purpose of predicting what results will occur from various operating changes should be based on complete operating data for the furnace in question.

TABLE II
Effect of Increasing Blast Temperature

1.	Hearth temperature	Increases
2.	Silicon	Increases
3.	Sulphur	Decreases
4.	Slag basicity	Increases
5.	Production	Increases
6.	Coke rate	Decreases
7.	Limestone	Decreases
8.	Slag volume	Decreases
9.	Gas heat credit	Decreases
10.	Burden ratio	Increases
11.	CO/CO_2 ratio	Decreases
12.	Top gas temperature	Decreases

Based on the Standard Case and the several kinetic rate equations, the trial-and-error mathematical model is then ready to function similarly to the specific blast furnace in question. Although the mathematical method can be handled manually, it is difficult and requires a great deal of calculating time. For example, to predict all the effects caused by merely increasing the blast temperature—say, 50 F—requires about 40 hr of calculating time. The final results will show changes in several hundred different numerical quantities related to the original standard case.

Table II lists a number of effects resulting in the above example. It will be noted that the first four changes are separated from the remaining ones because these effects are assumed to follow *only an increase* in blast temperature with no other external compensating changes.

For each of 720 cases, the computer solves a complete heat and material balance and production rate. The total number of computed answers for all cases will vary from about 150,000 to 200,000 numerical quantities. The results will include:

1. Production, coke rate and burden ratio.
2. Consumption of oxygen, injected fuel, limestone, ore, etc.
3. Slag volume and composition.
4. Top gas temperature, volume, calorific value and composition.
5. Stove load and stove heat requirements at 75 per cent thermal efficiency.
6. Carbon consumed by direct reduction or solution loss.
7. Net fuel gas heat credit after stoves.
8. Gas temperatures t_s and t_1 and all quantities included in kinetic equations 1, 2, 3.

The computer has practically eliminated the large amount of calculating effort required once the standard case calculations have been completed manually. However, after the computer results are tabulated, a large job remains in presenting the data so they can be useful and clearly understood. Although several ways might be used to show the final predicted results, the

general method used in this investigation is manual plotting and cross plotting. For the example cited, there would result 350 to 400 separate graphs showing what are considered the most important results and relationships.

RESULTS

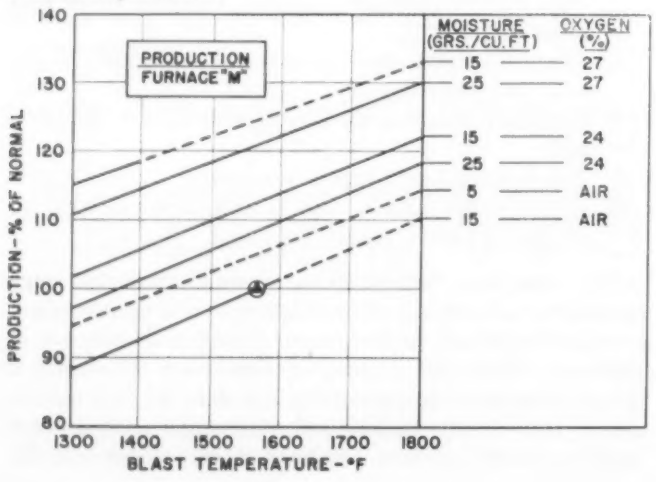
Production and Coke Rate—Moisture and Oxygen—Figure 1 shows the predicted production for a specific furnace "M" as related to blast temperature, moisture content and oxygen enrichment. Normal operating conditions for this furnace were: blast temperature 1555 F, coke rate 1390 lb per ton, and moisture 15 grains per cu ft. The large point on the graph represents the standard or reference conditions. It will be noted that six curves for different oxygen and moisture contents are plotted against blast temperature. The dashed lines or portions are considered areas of operation where furnace roughness might become a limiting factor. However, in this figure and those following, often a relationship will be shown for reference purposes though it may not be compatible with smooth furnace operation. An example of a situation in which furnace roughness would probably occur is the 5 grain moisture curve at the high blast temperatures shown. From the curves of Figure 1 the following conclusions can be drawn for this particular furnace:

1. To maintain constant production, the blast temperature should be increased about 12 F per 1 grain of moisture added (coke rate will increase 4 lb per ton).
2. At constant blast temperature (1555 F), production increases 13 per cent with 2 per cent oxygen enrichment and 15 grains of moisture.
3. At constant blast temperature, production decreases about 0.5 per cent per 1 grain of moisture added.
4. At 1600 F blast temperature, production increases 22 per cent with 6 per cent oxygen enrichment and 25 grains of moisture.

Figure 2 shows the predicted variations in coke rate for furnace "M" as related to blast temperature, moisture and oxygen. From these plots, the following conclusions can be drawn:

1. At 15 grains of moisture, the coke rate decreases about 0.4 lb per ton for each 1 F increase in blast temperature.
2. At constant blast temperature (1555 F), the coke rate decreases about 7.5 lb for a decrease of 1 grain of moisture.
3. For constant coke rate, the blast temperature should be increased 21 F for each additional grain of moisture.
4. At constant blast temperature and constant moisture, the coke rate increases 10 lb for each 1 per cent oxygen enrichment.

Figure 1 — Production goes up linearly with increase in blast temperature.



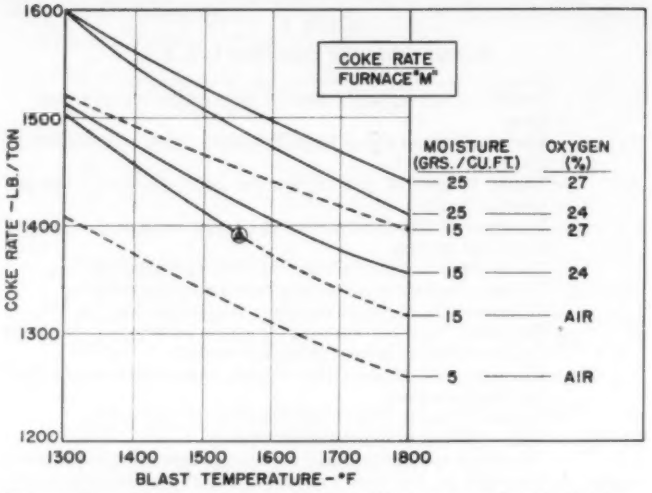


Figure 2 — Coke rate goes down with increase in blast temperature.

Caution should be exercised in comparing any of these reported predictions with other actual furnace data because of the significantly different characteristics between furnaces.

Production and Coke Rate—Natural Gas and Oxygen—Figure 3 is predicted production plot for furnace "K" as related to blast temperature, oxygen enrichment, and natural gas injection. The main difference between this figure and Figure 1 is the substitution of natural gas for steam. Normal operating conditions for this furnace were: blast temperature 1000 F, coke rate 1585 lb, and 4 grains of moisture. From the curves the following can be concluded:

1. To maintain constant production at constant wind, the blast temperature should be increased about 30 F per 1000 cu ft of gas injected per ton (coke rate decreased about 10 lb).
2. At constant blast temperature (1000 F), production decreases about 1.3 per cent per 1000 cu ft of gas injected per ton.
3. Production increases about 10 per cent with 1300 F blast temperature (300 F increase) and 2000 cu ft of natural gas per ton.
4. Production increases about 30 per cent with 1200 F blast temperature (200 F increase), 6000 cu ft of gas, and 8 per cent oxygen enrichment.

In actual tests run with natural gas, or other fuel injections, production results in several cases have been greater than expected. This is usually attributed to the furnace actually utilizing more useful wind. This evidently results from a much smoother stock descent and more uniform shaft gas distribution.

Figure 4 shows the corresponding coke rate plot for

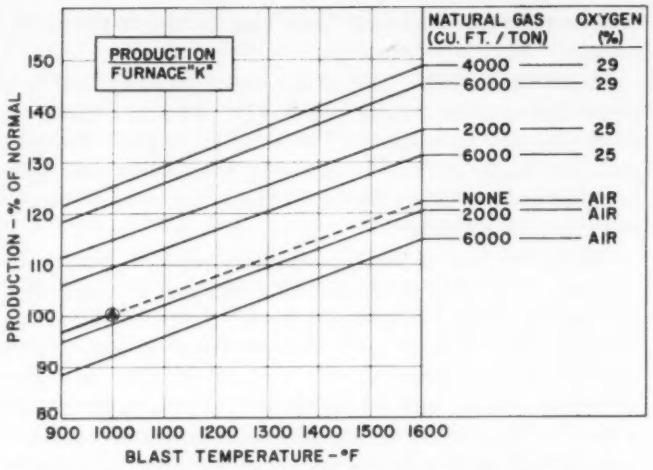


Figure 3 — For a constant blast furnace temperature, production goes down as natural gas used is increased.

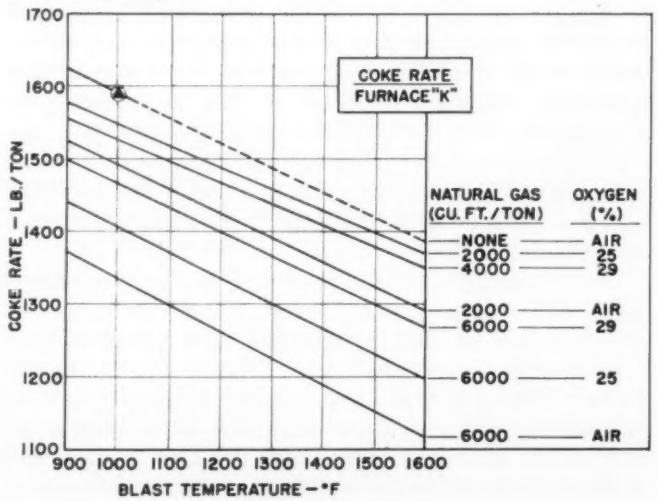
furnace "K." The immediate point of interest in this plot is the extremely low coke rates attainable with natural gas injection. For example, the following may be noted:

1. At constant blast temperature (1000 F), the coke rate decreases 95 lb per 2000 cu ft of natural gas per ton (production decreases about 2.5 per cent).
2. At 1500 F blast temperature, the coke rate is 1150 lb (decrease of 435 lb) with 6000 cu ft of gas.
3. At 1400 F blast temperature, the coke rate decreases to 1330 lb with 6000 cu ft of gas and 8 per cent oxygen enrichment. Note corresponding production increases about 37 per cent.

Thermochemical Aspects of Moisture, Natural Gas, Coke Oven Gas and Fuel Oil in the Blast Furnace—A complete discussion of the thermochemical difference between moisture, natural gas, coke oven gas and fuel oil as blast furnace reactants is beyond the scope of this paper. However, it is felt several comments should be worthwhile in view of the high degree of current interest in fuel injection and oxygen enrichment. Important points are:

1. All the above reactants (moisture, natural gas, coke oven gas and fuel oil) absorb high temperature heat from the combustion zone and are converted to hydrogen and carbon monoxide in the lower bosh region.
2. The ascending hot carbon monoxide and hydrogen carry heat upward into the furnace, thereby decreasing the temperature drop across the bosh and aiding in indirect reduction.
3. Hydrogen is a more active reducing gas than carbon monoxide in the higher temperature regions, but hydrogen is less active than carbon monoxide in the intermediate temperature zones of the shaft.
4. As water vapor is reduced to hydrogen and carbon monoxide, it *contributes oxygen* to the hearth but *takes away carbon.*
5. Conversely, as fuel gas or oil dissociate in the hearth, they *contribute carbon* but *take away oxygen.*
6. The heats of reaction vary over important wide ranges.

Figure 4 — Natural gas injection can reduce coke required very markedly.



Top Gas—Net Heat for Credit and Calorific Value—Since the blast furnace produces several times more tons of gas than iron, and all the effects related to the top gas are important to blast furnace operation, several top gas relationships are shown. These predictions were taken from a study on furnace "N" in which normal operating conditions were: blast temperature 1100 F, coke rate 1555 lb and moisture 4 grains. These curves show:

1. The net heat for credit decreases about 500,000 Btu per ton for each 100 F increase in blast temperature. This is due to a lower coke rate and more fuel gas required by the stoves.
2. At constant blast temperature (1100 F), the net heat for credit increases about 1,000,000 Btu for each 2000 cu ft of natural gas injected. Under this condition the extra top gas heat credit should offset about half the cost of fuel injected.
3. At constant blast temperature (1100 F), the net heat for credit increases 2,800,000 Btu with 4000 cu ft of natural gas and 6 per cent oxygen enrichment.

As mentioned earlier, the predicted results presented in this report may vary significantly from furnace to furnace for reasons already cited. From these results several interesting comparisons are noted such as:

1. The effect of oxygen enrichment on production varies over a relatively narrow range, i.e., from about 4.3 to 6.3 per cent increase per 1 per cent increase in oxygen enrichment (constant wind). This is undoubtedly due to the fact a certain degree of oxygen enrichment provides a precise increase in driving rate or heat generation and thus results in greater iron production.

2. The comments for oxygen enrichment also apply to the relationship of production with blast temperature. Predicted increases in production rate for six furnaces vary from 4 to 6 per cent for each 100 F increase in blast temperature.

3. The relationship of coke rate and oxygen is more complex as shown by the relative differences which vary between a decrease of 11 lb to an increase of 13 lb per ton for each 1 per cent enrichment. Such wide variations may be due to different heat exchange

efficiencies within the shaft. That is, a relatively short shaft or a furnace with a high top gas temperature may show substantial decreases in coke rate due to greater temperature gradients throughout the furnace. A furnace having large heat losses may also show appreciable coke savings with oxygen enrichment.

4. High blast temperature is similar to oxygen in compressing the high temperature zone. However, any increase in blast temperature directly adds heat to the furnace thereby causing a certain decrease in the coke requirements.

5. Variations in the amount of oxygen required are not unusually large as this particular quantity ordinarily runs between 800 and 850 cu ft per ton of iron per 1 per cent oxygen enrichment. Significant deviations from this range are probably due to such causes as: (a) Errors in the measurement of actual useful wind entering the furnace. (b) Errors in top gas composition. (c) Some furnaces actually use significantly different amounts of air per ton of metal produced.

SUMMARY

1. Every feasible means is under consideration to improve the iron blast furnace as to productivity, cost and control.

2. To help in this improvement a mathematical model for simulating the blast funace with electronic computers has been developed. This model is based on a complex trial-and-error method involving process kinetics, physical, thermochemical and mass balances.

3. The model has been of great value for: (a) Selecting and controlling such variables as blast temperature, moisture, oxygen enrichment and fuel injection to obtain optimum operating conditions. (b) Predicting effects of various changes prior to running tests or for making economic evaluations.

4. Studies made with the computer model on 15 blast furnaces indicate various optimum conditions involving oxygen enrichment, blast temperature and fuel injection can: (a) Increase basic iron production by as much as 25 to 30 per cent. (b) Decrease coke rate by 200 to 400 lb per ton. (c) Increase the calorific value of the top gas to 100 to 115 Btu per cu ft.

5. This study also shows quantitative effects of all blast variables and, in addition, shows important effects resulting from changes in charge materials, product composition, beneficiation, pressurization and furnace design characteristics (such as water cooling, etc.).

"SOME FEATURES OF BASIC OXYGEN STEELMAKING WITH BASIC HOT BLAST CUPOLAS"

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THE basic hot blast cupola—basic oxygen furnace process is one that uses a reducing basic slag in the cupola with an oxidizing basic slag in the oxygen furnace.

The basic reducing slag of the cupola removes sulphur from the cupola charge efficiently. The hot metal is therefore low in sulphur. There is no sulphur brought into the basic oxygen furnace by fuel, as in the open hearth furnace, with the result that there is a further reduction of sulphur.

Therefore, the process produces steel low in sulphur content. The degree of desulphurization is controlled by the amount of slag volume and the lime-silica ratio of both the cupola and oxygen furnace slags. This feature is important to the semi-integrated steel producer. It allows him to use a low cost metallic charge which is impossible to use in an open hearth and uneconomical to use in the two-slag electric arc furnace process.

The charge used in Acme's process consists largely of steel scrap, and the amount of phosphorus introduced by pig iron and iron scrap is necessarily low. This means that the blown steel is low in phosphorus content.

At the present time, Acme Steel does not require sulphur or phosphorus content in the steel to be below that produced by the other processes and no particular effort is made to do so. Nevertheless, the steel produced is generally less than 0.015 per cent phosphorus and 0.025 per cent sulphur content. Should the need occur, steel may be produced with phosphorus below 0.010 per cent and sulphur less than 0.015 per cent. In fact, many heats are produced with the latter analysis, even though there had been no intention to make these low specifications. One heat finished 0.006 per cent sulphur.

The Acme Steel melt shop has been in operation only five months. During this period, the training of crews and the "breaking in" of the equipment has been the principal objective. Nevertheless, a production rate in excess of 75 per cent of the expected rate is presently being attained. No attempt, as yet, has been made to utilize the full scope of the flexibility of this process. Because Acme Steel is a producer of strip steel, the control of residual or "tramp" alloys is important. For this reason, it will not be possible to take full advantage of the process' ability to use metallic charges consisting entirely of No. 2 grades of scrap.

No ferroalloys are added to the cupola charge or the hot metal produced. Therefore the hot metal charged in the basic oxygen furnace is low in manganese content. It usually runs from 0.35 to 0.65 per cent manganese. There is no steel ejected from the vessel during the blow and, likewise, little or no slag is thrown out. Because the silicon content of the iron is also low, the slag volume is small. These two factors tend to minimize the melting loss and result in a good yield. Keeping the area clean around and beneath the furnace presents no problem.

While searching for the best type of hot metal analysis, iron with a carbon content of 3.00 per cent and silicon as low as 0.08 per cent has been produced and been readily blown. Little steel scrap is charged in the furnace with this type of iron. During the past several months the hot metal has contained an average analysis of 4.2 per cent carbon, 0.50 per cent manganese, 0.100 per cent phosphorus, 0.028 per cent sulphur, and

0.20 per cent to 0.40 per cent silicon. The temperature of this iron, as measured by the immersion type thermocouple, is approximately 2400 F. (Optical pyrometer readings are about 50 F higher.) When the furnace is hot, this type of iron requires up to 30 per cent steel scrap charged in the furnace. This is comparable to that charged when using blast furnace hot metal. This means that ore, sinter, direct reduced metal or any of the other materials charged in basic oxygen furnaces, can likewise be used in this process.

Cupola slags are run every other hour and the hot metal is analyzed every hour on a routine basis. When desired, analyses are often made every 15 min. Cupola slag analysis, hot metal analysis, hot metal temperature, top cupola gas temperature, bustle pipe air temperature and pressure, top gas carbon monoxide content, quantity of air being blown, and the coke rate can be correlated immediately. Normally the lime-silica ratio of the cupola slag is maintained between 1.6 and 1.9 to 1. This slag will carry over 1.5 per cent sulphur. Usually the slag volume is between five and seven per cent of the metal charged. The very low sulphur content of the hot metal results from the careful correlation of all the above factors. The iron content of the slag is less than one-half of one per cent with the manganese oxide being around one per cent. This is a clear indication of the reducing characteristics of this process and explains the high yield obtained.

The carbon monoxide content of the gas varies between 15 and 20 per cent in normal operation. During short intervals after extra coke has been charged, this may rise to 25 per cent or even higher. The temperature of the iron flowing from the tap hole is close to 2750 F as measured by the optical pyrometer. The immersion thermocouple readings are approximately 50 F lower.

In addition to the indicating and recording carbon monoxide analyzer, there are instruments for hydrogen and oxygen analysis. The presence of hydrogen in the cupola gas will indicate a water leak, while the presence of oxygen will give warning of an explosive mixture. Should the oxygen reach two per cent, a warning is sounded and the power shuts off the precipitator. Low pressure in the gas system also shuts off the precipitator. A negative pressure could mean the presence of infiltrated air.

So far as we know, the Acme installation is the only one in which the entire steel production depends upon the successful operation of the basic hot blast cupolas.

There is no pig machine installed at Acme. The cupolas must, therefore, be capable of being shut down completely for short intervals and run continuously at very low production rates without detriment to the quality of the hot metal. This is true even though there are two 200-ton mixers. Delays have occurred in the steelmaking section when mixers were nearly full.

While each cupola is capable of producing at a rate in excess of 30 tons per hour, each cupola recently operated continuously for six days at an average rate of 12 tons per hour. This rate was reduced to 9 tons per hour for many consecutive hours. During this period, the analysis of the metal did not vary appreciably and the temperature of the iron did not fall more than 100 F.

The distance from the center line of the tuyeres to the surface of the hearth is 6 ft-2 in. This distance is considerably more than that of any other cupola. Even though there have been several occasions when the slag and metal accumulated for a considerable period of time in the hearth, no slag ever reached the tuyeres. No tuyere or tuyere cooler has failed in service.

Normally the slag volume varies from five to seven per cent, depending upon the amount of sulphur to be handled, and the lime-silica ratio is maintained from 1.7 to 1 and 1.9 to 1. Exceptionally clean scrap or a flux scales malfunction can increase this ratio to as high as 3 to 1; when this happens the slag thickens. If a separate slag hole were used under these conditions, the slag would solidify and shut down the operation. This is one of the reasons that the slag and iron are both brought out the same tap hole and separated in a "separator" outside the cupola. The iron keeps the slag flowing under all conditions.

After shutting down the blast, the cupola is drained of slag and iron, the worn tap hole plugged and the other tap hole opened. This operation takes about 45 min. There are approximately five to seven tons of iron in the cupola. The following day the cupola is shut down, the worn tap hole dug out and "repiped." This operation takes approximately one and one-half hours. There follows from four to six days operation with no further dealy. Thus, one tap hole lasts from five to eight days and 2000 to 4000 tons of iron are run through one tap hole. On one occasion, the tap hole was in service for 14 days.

The additional height of stack above the tuyeres has proven very valuable. The gas leaves the cupola at 250 F. This means that there is considerable sensible heat transmitted to the stock. It is believed that this is a contributing factor to the successful use of large pieces of steel scrap. Two-thousand lb bundles are in regular use. A 5000 lb coil has been inadvertently charged. There was no noticeable bad effect but it is believed that the use of such large pieces is not good practice.

The most valuable result of the high stock column has been to minimize the effect of charging delays. The extra stock has allowed operation to continue at reduced blast for periods up to three hours duration with no detrimental effect on the quality of the iron. These delays were usually caused by occasional failures in the automatic charging system.

Many water cooled cupolas have the top section suspended independently of the lower section. This means there must be an expansion joint between these sections. This is a source of trouble. When using a gas system under positive pressure, this joint would leak profusely. The Acme cupola has a shell thickness of 1½ in. The 40 ft above the tuyeres tapers from 10 ft in diameter to 11 ft at the tuyeres. The 8-ft vertical distance from the tuyeres tapers to 13 ft in diameter at the base plate. The whole is mounted on massive foundations with the top hopper section an integral part of this shell. The gas take-off and hot blast lines have expansion joints. Water flows down the outside of the shell and the top hopper is of double walled construction with water circulating inside these walls. In "blowing down" the cupola, the top gas temperatures have reached 1700 F with no noticeable effect.

It might be of interest to repeat that the dry precipitator gas cleaning installation on the oxygen furnace is

guaranteed to have a maximum of 0.024 grain of solid effluent at 250 F stack temperature. The wet gas cleaning system, with the wet precipitator installed on the cupolas, has a guaranteed maximum of 0.01 grain per cu ft with a gas temperature of 125 F.

The basic hot blast cupola—basic oxygen furnace process has inherent characteristics which lend themselves to the efficient use of labor, equipment and capital investment costs. While it uses a large number of labor saving devices and automatic equipment, it is very compact.

By using five short parallel aisles, the melt shop, with an initial capacity in excess of 400,000 tons per year, is housed under one roof. The oxygen producing, water pumping, water clarification, and track hopper facilities are the only ones not under this roof. These require little supervision and only a small amount of labor. The area covered by this building is approximately 500 ft long and 350 ft wide. Three of the aisles are conventional crane aisles, while the bin and equipment aisles have sections which rise vertically to a height of eight floors above ground level.

Metallic charge materials enter either end of the stock yard and move across the shop in short parallel lines to the cupolas and oxygen furnaces. The hot metal melts the scrap at the converters, and the liquid steel moves to the casting aisle. Ingots emerge from either end of the casting aisle and go to the soaking pits. Coke and fluxes are unloaded in a track hopper and are transported by belt to the top of the bins. These materials descend by gravity to a belt system at the cupolas and a monorail system at the converters. In this manner the nonmetallics enter the production cycle without interrupting the flow of metallics.

"USE OF OXYGEN LANCES AND BASIC BRICK IN OPEN HEARTH FURNACE ROOFS"

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THIS paper deals with two technological improvements that have aided materially in increasing the steel producing capacity of open hearth furnaces.

The development of a practicable method of introducing gaseous oxygen into the bath throughout the heat cycle for thermal and oxidation requirements has improved production rates by reducing heat time.

The development of a basic roof construction that is economical and less sensitive to the wide variations in temperature (sometimes unavoidably encountered in open hearth operation) is a major contribution to increased production. Additional furnace availability results from longer roof life and fewer delays. The furnace also can better withstand the higher driving rates required to secure maximum production.

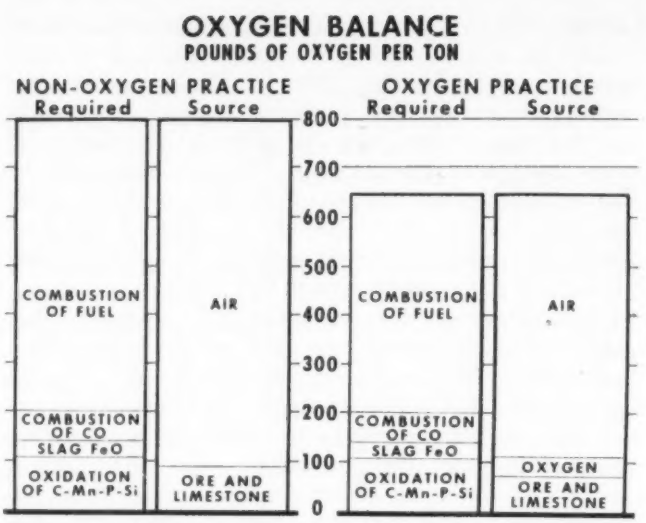


Figure 1 — Even with oxygen practice, air supplies the major requirement.

OXYGEN IN THE OPEN HEARTH

It might be well to consider briefly the oxygen and thermal requirements of the basic open hearth process for those not familiar with them. The pounds of oxygen required for making one ton of steel and the sources from which the oxygen are obtained are shown graphically in Figure 1. Data are approximate and are for a heat using about two-thirds molten iron in the charge. The oxygen balances for nonoxygen and oxygen practices are shown.

It is interesting to note that with 200 to 600 cu ft (17 to 50 lb) of oxygen per ton for improving combustion of fuel, we are only talking of 3 to 8 per cent of the total combustion oxygen requirements. The 300 to 600 cu ft (25 to 50 lb) per ton used for bath oxidation is about 20 to 40 per cent of the total requirement for this purpose.

The speed of the open hearth process is mainly dependent on the rate at which heat can be supplied to the bath for the melting of metallics and slag and the reduction of iron oxide.

The very high utilization of the heat generated by direct oxidation of the bath with oxygen should be noted. Almost all of the heat is transferred directly to the bath and is available for useful work. When conventional fuels are burned over a bath of molten slag and iron, the efficiency of utilization of the heat generated is very low—about 15 to 20 per cent—because with a combustion flame temperature of approximately 3500 F, the waste gases leave the furnace proper at 2800 F to 3000 F. Of course, some of this heat in the gases is recovered in regenerators and waste heat boilers.

PRESENT OXYGEN PRACTICE

With roof lances now installed and operating on 73 of the 256 open hearth furnaces in United States

Steel Corp., Table I gives the normal ranges of the various factors involved in present operation.

TABLE I
Present Ranges of Operating Variables

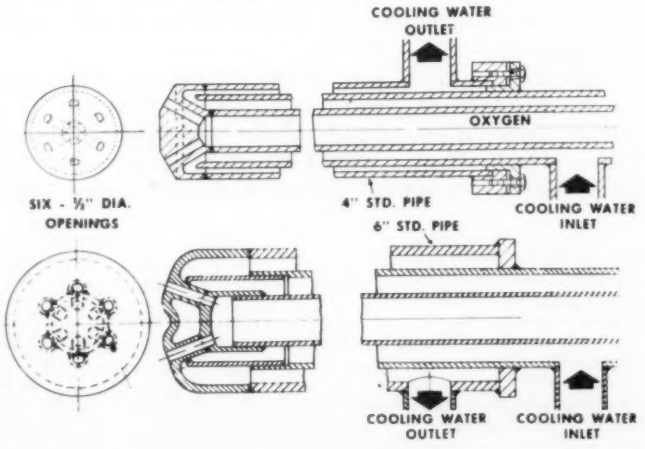
Item	Min.	Max.
Furnace size, tons	100	350
No. lances per furnace	1	2
No. openings per lance	6	6
Size openings, in.	3/8	5/8
Angle of openings with vertical, deg	20	30
Distance—lance tip to steel bath, in.	6	18
Oxygen flow—cfhr:		
Per lance	12,000	40,000
Per opening	2,000	6,500
Per ton	85	155
Per sq ft hearth area	20	45
Velocity of flow, fps	550	1,000
Cu ft of oxygen per ton of ingots	200	700

These furnaces are all operating on hot metal practice. The hot metal in the charge varies from 40 to 75 per cent of total metallics charged. The time for starting the blowing of oxygen in the bath varies, in individual plants, between 0 and 30 minutes after the last hot metal addition. With lower percentage hot metal charges, oxygen has been used even before hot metal addition to assist in heating and melting the scrap. This permits earlier addition of hot metal and reduction in heat time.

A given amount of oxygen, whether supplied through a single lance or through multiple lances, will, in general, do equivalent work. It is desirable to employ a single lance, if possible, for operating and control reasons, but it may be necessary to install multiple lances to keep the various factors within optimum ranges for control and the prevention of high repair and maintenance costs to the furnace.

The two types of lances which are in general use in our plants at the present time are shown in Figure 2. The heads are of high-conductivity copper and the balance of the lance is steel. The head of the 6½-in. diam lance is of cast copper, and the head of the 4½-in. diam lance is either forged or machined to shape from a 4½-in. diam forged copper round. All of the lances in use have six holes, ⅜- to ⅝-in. diam, at angles of 20 to 30 degrees from the vertical. The life of the lances has been improving and is now approximately 80 to 100 heats per head.

Figure 2 — Two types of lances are in current use.



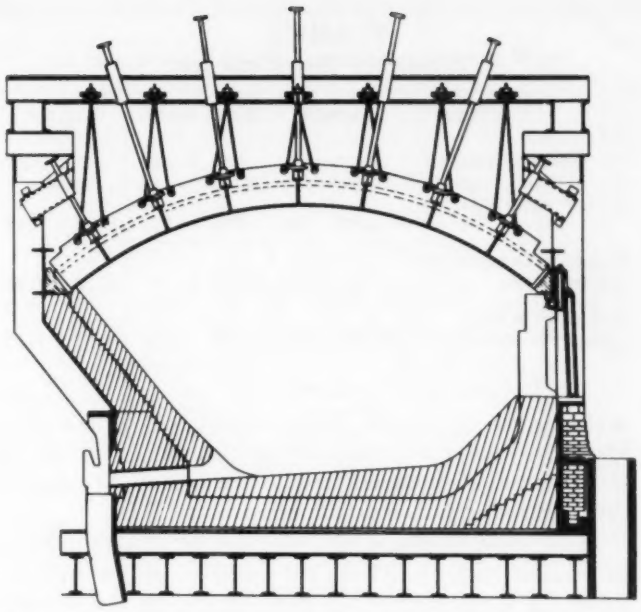


Figure 3 — The cross section of basic roof shows details of suspension and holddowns.

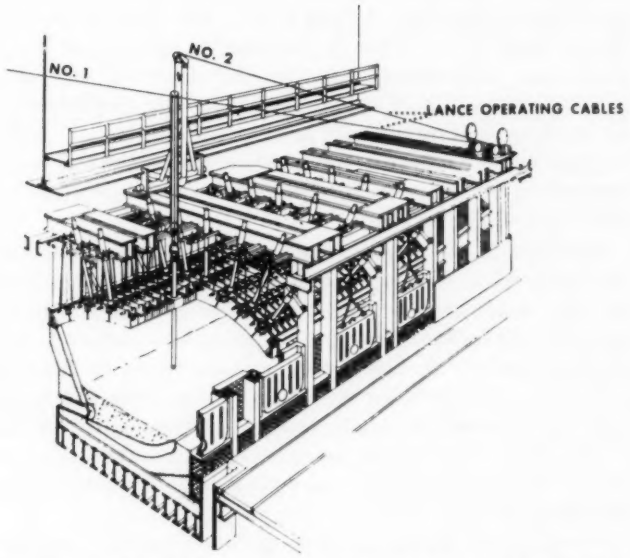


Figure 4 — Two oxygen lances are used with this basic roof.

RESULTS

Table II shows a summary of operating results at three of our plants. The data are on groups of heats made with and without oxygen on the same furnace during the same period with the same product mix. Data from over 600 heats are included.

These data indicate that with the use of 300 to 600 cu ft of oxygen per ton of ingots, we obtain an improvement in heat time of 10 to 25 per cent and a saving in fuel of 18 to 35 per cent.

A small loss in yield has been generally indicated, apparently due to higher iron oxide in the flush slag, caused by the faster and more active flush obtained when oxygen is used immediately after the hot metal addition. The iron oxide content of the tap slag is normal for a given tap carbon. The loss in yield could probably be eliminated or reduced by earlier charging of hot metal or by delaying the use of oxygen.

In our oxygen practice, a carbon drop of 0.75 to 0.90 per cent per hr is obtained. Sulphur elimination

TABLE II
Results with Oxygen Roof Lance

Plant ▷	Fairless		South Works		Clairton	
Group of Heats ▷	1	2	1	2	1	2
Oxygen used (cu ft per ton)	571	480	375	543	374	513
Reduction in tap-to-tap time hr-min	1.42	1.40	2.34	1.51	2.25	1.58
Reduction in Fuel (mm Btu per ton)	0.72	0.84	0.61	0.95	1.37	1.33

performance appears to be improved, as evidenced by lower final sulphur content of the steel or a decrease in the amount of lime required. This is probably due to the early and rapid solution of lime in the slag.

The results shown in the table are for heats produced when only one or two of the furnaces in each of the shops were equipped with roof lances. As the number of furnaces equipped with lances increased, it was evident that the optimum benefits were not always obtained. Need for training, on the part of the men, contributed to this. A larger part was due to the inability to service properly the greater number of heats produced. One important result observed was the virtual elimination of excessively long heat times caused by stickers, low melts, cold heats, etc. The ability of the oxygen lance to rapidly put heat directly into the bath, regardless of slag or preheat air conditions, is of great assistance on these abnormal heats.

Because of the speeding up of rates of reaction and production, it is important that the operator keep closely informed of the temperature and carbon content of the bath so that proper action can be taken without delay. A delay of a relatively short time in making a limestone or ore addition, or reducing firing rate, may result in an increase in temperature of the bath. This could cause serious damage to the furnace structure and bottom, as well as consequent delay for repairs.

Continuous determination of bath carbon content and temperature would be a very valuable tool for this process; it may permit further increases in oxygen usage and consequent reduction in heat time and gain in production. Our experience has shown that further gains could be made by the increased use of oxygen, but the control is more difficult and the incremental benefit of the increased amount of oxygen is less. Also, even with adequate servicing equipment, in a stationary open hearth furnace certain minimum times are required for operations, such as charging the furnace, slag removal, setting spouts, charging hot metal, etc. Our practice is aimed at maintaining smooth, efficient operation of the furnace and arriving at the proper tap carbon, temperature and slag condition at the same time, with a minimum demand for exceptional skill or effort on the part of the furnace operator.

AUXILIARY REQUIREMENTS AND FACILITIES

Experience with oxygen roof lances has shown that an improvement in heat time of 10 to 25 per cent can be obtained, along with a savings in fuel consumption of 18 to 35 per cent.

To gain the full advantage of the reduced heat cycle, the shop must be equipped to handle a greater number of heats and larger quantities of materials. Hot metal must be available in larger amounts and adequate handling equipment supplied. This may require additional ladles, reladling stations and floor cranes. Added stockyard facilities, charging boxes, buggies and charging machines may be necessary to handle steel scrap and other cold materials more rapidly. On the pouring side, an adequate complement of pit cranes, ladles, molds and ingot buggies must be provided. More slag pots and cars may be necessary if slag is handled in this manner. If slag is allowed to run on the ground, additional mobile equipment may be required for rapid removal.

BASIC BRICK ROOFS

Prior to 1947, several furnaces in this country had been equipped with basic main roofs of the fully-suspended type. Results from these early trials showed increased roof life, but were not sufficient to justify the higher cost of construction and refractory consumption. Therefore, experiments with full basic roofs were discontinued in most cases. Subsequently, the so-called "zebra roof," with varying amounts of basic brick inserted in silica main and port roofs, was developed and used where economical.

The first sprung basic main roof at Fairless Works was installed during May, 1957, on No. 2 furnace, which was equipped with two oxygen roof lances. It was not a complete roof, the basic section extending only from No. 2 to No. 4 door on a five-door furnace, from front to back skew. It was a 12-in. roof with 15-in. ribs, made up of standard keys and straights in the 3-in. series of metal-encased, internally-plated, chemically-bonded chrome magnesite brick. The rise of the arch was 51 in. in a 24-ft span, and an expansion of 5 in. was allowed in the arch. There was no intentional longitudinal expansion allowance.

The furnace was placed in service in June, 1957. The roof dropped about 3 in. during heating when the material used for expansion allowance burned out. The crown of the roof dropped gradually through the entire run and lost its shape. On the 91st heat, the center section fell in and the furnace was shut down.

Even though its life span was relatively short, the experimental panel roof provided the following valuable information:

1. The rate of wear on the brick was low, even though the roof had lost contour early. Out of 12 in. of initial brick thickness, some 9 to 11 in. remained. This was encouraging.

2. The drop of the roof during the furnace heat-up

TABLE III
Initial Basic Roof Campaign, Fairless Works with Oxygen Lance Practice

No. of heats	368
Average heat size, tons	342
Total tons produced	126,052
Tap-to-tap time, hr-min	7-59
Tons per operating hr	43.04
Hot metal to ingot ratio	0.735
Furnace yield, per cent	85.5
Fuel consumption, Btu per ton	2,350,000
Oxygen, cu ft per ton	439

indicated that the expansion allowance could be eliminated.

3. Because of its slow downward movement, it was believed that a suspending medium of the simplest type, such as suspended steel sheets which would fuse to the metal-encased brick, would be sufficient to keep the crown from dropping.

4. The panel test showed that the holddown supports were necessary in order to maintain the roof contour, and that the holddowns could be set rigidly before the fuel was put on the furnace.

With this knowledge gained from the experimental panel, the first knuckle-to-knuckle roof was installed on the same furnace in December, 1957. The roof was constructed, as before, of internally-plated, metal-encased, chemically-bonded chrome magnesite brick, with 15-in. ribs and 12-in. valleys. The principles of construction, showing methods of suspension and holddowns, can be seen in Figure 3. The $\frac{3}{16}$-in. steel plates used for suspension were on 18-in. centers in one-half of the roof, and on 9-in. centers in the other half. As can be seen from the drawing, the entire construction of suspending plates and holddowns was such that the roof was held rigid during its entire life without any allowances for expansion or contraction.

An isometric drawing, showing a furnace with basic roof and equipped with two oxygen roof lances is shown in Figure 4.

No. 2 furnace was again placed in service on January 14, 1958, and it was not taken off until May 17, 1958, after a run of 368 heats. Patching during this campaign amounted to only 19 per cent of the total roof area.

Table III gives the operating statistics for this first complete roof. Special attention is drawn to the tap-to-tap time of 7 hr-59 min; the production rate over 43 tons per operating hour; the fuel consumption of 2,350,000 Btu per ton and the total of 126,052 tons produced during the campaign.

Needless to say, the success of this roof was very gratifying and it confirmed the conclusions drawn from the experience on the experimental panel roof.

With this favorable experience, basic roofs were installed on all other furnaces at the Fairless Works.

RESULTS AT FAIRLESS WORKS

Table IV gives the results on the completed basic roof campaigns at Fairless Works, as of July 14, 1959.

The table shows that 13 furnace campaigns have been completed in which the roofs were constructed with unburned, chemically-bonded basic brick. The average roof life was 405 heats and the average tons per campaign was 139,324. On the last six campaigns, the roof life averaged 459 heats. Part of this improvement resulted from a better method for blowing graphite and dust from the top surface of the roof, and an improved hot-patching technique. The roofs in both campaigns on No. 5 furnace, and in the last campaign on No. 2 furnace, were sprayed on the hot face with a chrome slurry material during the latter part of their campaign. This material proved beneficial in reducing the amount of roof patching required, and in extending the roof life.

Differences in the composition of the brick between 45 per cent MgO and 63 per cent MgO have shown no significant effect on roof life.

TABLE IV
Completed Basic Roof Campaigns—Fairless Works

Type brick	Fce No.	Roof life		Brick		
		No. heats	Tons produced	Size, in.	Internally plated	Mgo, Per cent
Unburned chemically bonded chrome magnesite	2	368	126,052	3x4½ keys	Yes	45
	5	398	136,916	3x4½ keys	Yes	45
	2	383	131,482	3x4½ keys	Yes	45
	8*	374	129,176	3x4½ keys	Yes	45 63
	7	289	100,154	3x4½ keys	Yes	45
	3*	339 220	116,968	3x4½ keys	Yes	45 63
	1	356	122,839	3x4½ keys	Yes	45
	6*	453	155,845	3x3 keys 3x4½ keys	No Yes	45
	5	413	142,811	3x4½ keys	Yes	45
	2	550	188,879	3x4½ keys	Yes	45
	8	463	159,270	3x4½ keys	Yes	45
	4	481	165,063	3x4⅛ keys	Yes	63
	7	394	135,761	3x4½ keys	Yes	45
Burned magnesite chrome	9	295	101,244	6x3 wedges	No	71
	3	291	101,309	6x3 wedges	No	71

* ½ roof of each type brick.

The cost of the Fairless-type basic roof, installed from knuckle-to-knuckle, is 1.8 times the cost of a 15-in. silica roof with 21-in. ribs, with an 18-in. "zebra" drop section front and back with 24-in. ribs. The life of silica roofs in furnaces which used oxygen lance practice averaged 190 heats during the period from October 1, 1958 to July 14, 1959, while the basic roofs during the same period averaged 408 heats. It is apparent from the above figures that the roof cost per ton of ingots is lower for the basic roof than for the silica roof. The benefits of increased production, less outage time and less hot patch time are additional factors in making the sprung basic roof a most valuable contribution to improved open hearth operation.

PRESENT STATUS AND RESULTS

As of March 1, 1960, 118 open hearth furnaces in United States Steel Corp. had basic main roofs, and the results have been uniformly favorable. Ninety-three roof campaigns had been completed, as of March 1, and the program of converting to basic roofs is continuing.

The construction at all plants is essentially the same as the Fairless design and has only varied in minor details. Of course, improvements have been progressively made.

The essential difference between the Fairless-type of construction and that previously used in this country and in Europe is that the present-type roof is laid up tight—without longitudinal expansion allowance and only minor lateral allowance—and is held rigid before lightup and throughout the campaign. Also, it is

important that the suspension plates extend across the roof from skew to skew, between roof rings. In previous basic roof construction, substantial expansion allowances were made in both directions. Holddowns, when used, were only to keep the roof from losing its shape after the furnace was in operation. Also, the plate suspension system with metal-clad brick has resulted in a roof of monolithic structure, after heating, which does not collapse when cooled down.

The necessity for holding basic brick roofs at temperatures over 2500 F to prevent spalling and failure has been stressed in this country and abroad. At first, this was a matter of great concern to us because, from a practical standpoint, it is almost impossible to insure against forced or unscheduled shutdowns and cooling. It has been very gratifying to find that with the Fairless-type of construction, no noticeable loss in roof life has been experienced from cooling of the roof and reheating, even for extended shutdown periods of 4 to 5 days (which have been necessary in some cases for complete rebuilds of ends and slag pockets).

The basic roof can be successfully patched in the same manner as a silica roof, but when basic brick is used for patching, suspension plates must be used to prevent sagging. The furnace can be brought up to temperature at a faster rate than with silica roof without apparent damage.

The longest life of a basic roof using two oxygen lances on practically all heats has been 550 heats at Fairless Works. In this campaign, 188,879 tons of ingots were produced. Several roofs on furnaces in other shops without oxygen lances have exceeded this number of heats, the longest life having been 779 heats.

"PRESIDENT'S ADDRESS"

By BENJAMIN F. FAIRLESS,
President
American Iron and Steel Institute
New York, N. Y.

IT is only natural now that, in this first year of a new decade, we should be wondering what is in store for the steel industry in the '60's.

The 1960's will present to our industry new problems, new conditions, new challenges—as well as the promise of continued growth and expansion.

Of the problems, I would suggest four as being the most urgent, basic and plainly visible today. They are:

1. Finding a way to achieve labor peace in the industry.
2. Continuing the present program designed to improve the efficiency of steel plant operations.
3. Offsetting the steadily rising competition from other materials and from low-cost steel produced abroad.
4. Maintaining a fair level of profits, and a fair allocation of the benefits of productivity increases, so as to attract the capital needed for essential improvements and expansion.

All of these problems are closely related. Their common denominator is competition.

One of the great changes in American life has been the rise of huge labor unions, and one of the most powerful of these is the Steelworkers Union. Since the end of World War II, as you well know, there have been five major steel strikes. These strikes cost America over 80,000,000 tons of steel. The aggregate cost of these strikes to employees in lost wages has been calculated at over one and a half billion dollars.

How can peace be achieved? This is a basic problem to which all of us must devote our utmost attention, if the industry is going to survive and prosper.

I do not know the solution to this problem but I do know that the answer does not lie in any effort to turn back the clock. Unions are here to stay, and no one in the steel industry wants, or believes it possible to destroy the union. It is needed both by the employees and the companies.

No, the question is not how to break the union, but how to make the collective bargaining process work better for all concerned. Many factors are involved in this effort, but one thing is clear: the companies will need to do a more effective and convincing job of explaining their problems to the employees, to their unions, to the communities in which they operate and to the country.

The need is for a greater degree of industrial statesmanship than ever before on both sides of the bargaining table—a statesmanship which will give even more serious thought to the public interest and to the welfare of the whole economy. The new labor agreements provide new avenues of approach to this problem, and I hope that this work will show more constructive results than our similar efforts in the past.

I have put as our industry's number two problem that of increasing the efficiency of operations beyond the present point. Here, we know is a two-fold requirement. It is for real cooperation on the part of the union and employees and for constant improvement in the technology of production. Only by the unity of these means, in full measure, can productivity be increased while costs are held in check.

At the heart of this problem is the fact of ever-mounting competition.

The major cause for the influx of foreign steel, as we all know, is our steadily rising employment costs as compared with the much lower wage costs of foreign producers.

Our wage costs are as much as seven times higher than theirs. As a result, of course, they have a wide margin on which to invade our markets and undersell us on many products.

Solutions to the problem which assume the American steel industry is self-contained are no longer valid—if they ever were.

Consider our imports of iron ore. Last year we imported almost 40,000,000 tons, an all-time record. That was 28 per cent above such imports in 1958. And in 1950, the record for the time was only some 9,000,000 tons.

We are scouring the world in search of raw materials. That is a major reason I say and say again: the answer

to our problem of foreign competition is not in high tariff barriers. That's a political game any number can play. If we raise trade barriers against other countries, they can retaliate by raising them against us. We need the rest of the world as it needs us.

We hear if often said—and many people believe—that we can compensate for the wage differential with superior technology. I believe we are still the most efficient producers of mass materials and goods in the world.

But we must face reality. American industry has no monopoly on modern efficiency. We have no corner on ingenuity or research. Many of our neighbors in this world community are already fully capable of competing with us in techniques and facilities. Therefore we must do everything in our power—management, employees and union—to hold our own against this competition.

In our favor is the fact that, in competition with foreign steel, price alone is not the only factor. Quality of material, promptness of delivery and service are also important considerations for the buyer. And on these points American steel has the edge.

The purpose of success in competition is to maintain a profitable industry. And herein lies the fourth problem to be faced in this decade.

The opportunities for growth to which we look can be realized only if capital is available for taking advantage of them.

More money will be needed than in previous decades we have known. It follows that the industry will have to set itself more diligently than ever to the task of obtaining that money.

The key, of course, will be the same as it has always been in this free country of ours. There must be adequate earnings, to attract and hold investors who want a fair return on their investment. If steel does not meet this requirement, they will invest their money elsewhere.

Every company therefore must not only achieve an efficiency which provides a sound profit; it must also preserve its own fair share of the returns from that efficiency. And, further, it must keep its position clear to its employees and the public, so that its intentions and decisions are understood.

This industry has many advantages, as well as problems as it enters the seventh decade of the 20th Century in a completely new world. It has a good plant, a superior product, sound management and a fine working force. I believe the problems will be solved if the industry will concentrate on these points:

1. Work earnestly with our employees and their unions and the public in an effort to achieve lasting industrial peace.
2. Increase productive efficiency through every means possible.
3. Intensify our research program developing new steels and new processes, and opening new markets.
4. Maintain our leadership in every area of competition.
5. Expand our export markets and develop new export opportunities.
6. Step up our efforts in public relations, promotion and advertising—to insure greater appreciation of steel's use and value, and its contributions to the economy.

"OUR DISAPPEARING DOLLARS"

By JOEL HUNTER,
President
Crucible Steel Co. of America
Pittsburgh, Pa.

AS we move into the decade of the sixties, we must continue to have a healthy steel industry, adequate to supply the nation's commerce and provide for its defense. This means a profitable industry, capable of generating through its own operations most of the funds required for its own maintenance and for such enlargement as the country's growth might require. This is not merely a concern of the men who make and sell steel; every citizen has an interest, because steel is so truly basic to our whole economy. Profits must be realized, in spite of steadily rising cost levels and limits on prices which can be placed on the goods we sell. These limits are imposed by competition: among ourselves; from other materials which are increasing in importance and displacing steel; and finally, there is the steel from revitalized foreign plants which have captured a considerable part of the markets we formerly enjoyed. While we have long been producers of one of the lowest-price structural materials, we have now come to understand that the rate at which steel prices will increase in the future must be substantially less than in the past.

In consequence, I venture to say there has never been a time when the American steel industry has given more attention to the reduction of costs of all kinds. At every level of management, the drive is on to reduce costs. Our industry, has scheduled $1,600,000,000 for plant improvement in 1960—second only to the $1,700,000,000 spent in 1957. According to public reports, little increase in capacity is expected from this spending. The greater part is for the purpose of reducing costs. Spending of this kind is necessary to modernize our plants, reduce manhours and speed production. Enlightened labor union leadership recognizes the urgency of cost reduction from the standpoint of labor and, indeed, national welfare. All thinking people recognize the importance of our having efficient, lowcost, steelmaking facilities. Over a century of industrial history demonstrates conclusively that saving of human labor is the way to improve the lot of the common man.

Depreciation is important in steel because steel plants cost so much and last so long. Industry sales in recent years range from $0.80 to $1.20 for each dollar of plant investment; 1959 was $1.01. Few other industries are this low. Paper, for example, was $1.40 last year, chemicals $1.51, textiles $2.59 and electrical machinery $3.67.

We have two factors which jeopardize the value of plant investment: the decline in value of the dollar

and technological obsolescence of both plants and processes. They directly affect plant values, and the annual recognition of depreciation should take both into account.

What is to prevent us from writing off our million-dollar property addition at a faster rate than $40,000 a year? Why should we not say that 25 years is too long a time? Even though the facility might reasonably be expected to have a physical existence of 25 years, we can have no assurance that we will have any use whatever for it 25 years later. Neither can we expect our currency value to be the same 25 years from now.

This is fine; this might do very well to cover both obsolescence and inflation, but unfortunately we cannot do it. We cannot do it because the rules say we cannot. What rules? Who made the rules? First of all, the income tax rules. When corporation income tax rates are 52 per cent for the federal, and more for the states, accounting practices are very strongly influenced by the rules which govern the taxability of income. It is said with some logic: "Why write off more depreciation if it is not allowed as a deduction for tax purposes?" In theory, the income tax is imposed on net income. In practice, income is very narrowly and strictly defined by Treasury Department rules and a great body of statutory and judicial law. What is income to the Treasury Department is not necessarily income to the economist or to the owner.

One of these Treasury Department rules is known as Bulletin F, a rather remarkable document, in which the useful lives and depreciation rates are set out for a large number of different kinds of property. The Treasury Department says it is only a "guide"; but Revenue agents, being only human in spite of what some people may be inclined to think at times, seem to use it as a bible. After all, the Bulletin lives are long and the rates are low, and there is nothing else in official print. Fortunate is the taxpayer who can get shorter lives approved. I go back into history only because the same theory still prevails: the taxpayer is required to carry the burden of proof.

Aside from the tax collector, there is another influence on depreciation which arises from the fact that basic steel companies are large enough to have a number of shareholders and be registered with the Securities and Exchange Commission. Most steel company stocks are listed on security exchanges, and the accounts must be audited by certified public accountants who must certify to their annual reports.

Accountants are governed by what is known as "generally accepted accounting principles" in their certification of financial statements. This does not always coincide with the income tax rules. The accounting rules which have been formally stated over a period of 25 years or so are somewhat like the common law. A rule has been issued from time to time to cover particular situations which seemed to require it, but no comprehensive official code exists which is expressive of all generally accepted accounting principles. This may have been a wise approach, but the result has been varied with incomplete coverage of the issues; sometimes fundamental inconsistency seems to result from the application of the rules. A similar comment can be made with respect to all case law, even decisions of our highest tribunal.

While by no means identical, the rules defining taxable income and accounting rules for determining income have had considerable influence, each upon the other. Generally accepted accounting principles have governed the determination of taxable income in the absence of special laws or regulations to the contrary. On the other hand, lifo and accelerated amortization under Certificates of Necessity are instances where changes in the tax law influenced general accounting in practice if not in strict theory.

The United States is not the only country which has used greater depreciation allowances to stimulate industrial development. Canada did the same thing and doubled its ingot capacity in 15 years. If we compare the 19 more industrialized countries of the world with the United States, we find the laws of eight countries permit shorter lives while seven allow accelerated rates of depreciation above our rates. Ten permit an additional writeoff in the first few years of the life of the property, as an incentive for modernization. In Great Britain, Belgium, Holland and Sweden, this amount is between 30 and 33⅓ per cent, and in Argentina it is as high as 50 per cent. In eight nations, the entire plant was revalued to correct for inflation which had occurred, and in five, depreciation is permitted to exceed cost in the aggregate without revaluation or above the revalued cost. These numbers do not add up to 19 because most of the 19 countries have more than one of the features I have mentioned. But the facts add up to the sad conclusion that the United States' tax depreciation laws are the most restrictive in the world.

It is unfortunate that the extra writeoff available under our Certificates of Necessity must reduce ordinary depreciation of the future. If covered by a Certificate, an imaginary $1,000,000 tool might have been the source of $800,000 in writeoffs by 1959. Under present rules, we would have only $200,000 remaining historical cost value to spread over the next 20 years. The annual writeoff thus goes from $160,000 for 5 years down to $10,000 for the next 20 years. It is not entirely coincidence that the writeoff of $160,000 permitted under the Certificate is exactly the same amount required if straight line depreciation of $40,000 were corrected for obsolescence and inflation in the illustration I used a moment ago.

Whatever the reasons or background may be, it is difficult to explain how we can have $160,000 in expense one year and $10,000 the next, for the very same thing. There has been no physical change, the machine is there, running just as it did a year ago, but the figures come up with this surprising difference. One is tempted to say they cannot both be right and yet hundreds of companies are saying they are right, in effect, by printing income statements in which are embedded thousands of instances of this kind. These income statements are certified by the CPA's and accepted by the SEC and stock exchanges, and distributed to our shareholders and general public.

There is again, the dilution of the single transaction in the large body of the whole. Nevertheless, industry is now in the unhappy position of being forced by the historical cost rule to recognize less than an adequate amount of depreciation in 1960 and the future.

The dollars invested in our plants are disappearing and we are reported more income than we actually have,

because the tax and accounting rules require it. Reporting more than our economic income is a serious matter. Taxes are greater than they should be, dividends tend to be too high, and there is less available for plant improvement.

Our disappearing dollars are lost to the steel industry and the national economy. Even the Treasury benefits only in the short run. Every dollar spent for new plant produces more than $0.25 in taxes on corporate and personal incomes, and the new plant gives rise to income which is taxed as long as the plant lasts. It can be proven statistically that, instead of diminishing tax revenues, more liberal depreciation allowances will actually increase them by encouraging the building of new income-producing plant. Any loss in the initial period is more than offset rather quickly by the enlarged tax base.

"THE WISE MAN'S EYES"

By LESLIE B. WORTHINGTON
President
United States Steel Corp.
Pittsburgh, Pa.

THE steel industry still has many challenging problems confronting it, but I think the keystone in our progress as a vital, growing industry in the years to come is the sale of our products in ever greater volume against some of the toughest, most resourceful competition we have ever faced.

A few writers of financial columns have been intimating recently that steel is no longer a growth industry. This is completely incomprehensible to me. Perhaps if we closed down our sales offices, called a halt to our research and development, and just sat back and hoped that sympathetic people would continue to order some of our products, we would fail to grow. But we are not about to do that.

We have a tremendous asset—steel itself, for steel is the world's most versatile and lowest-cost material for most applications. Furthermore, the potential for improving its strength, its corrosion resistance, its hardness and toughness, and its aesthetic properties, is enormous.

New steels, and just as importantly, *existing* steels, used with greater engineering efficiency—creatively—with imagination can give us the means to achieve greater material progress than we have ever known . . . provided they are *used* properly—and this means *sold* properly.

One of the most pressing sales problems we all face is competition from other materials. Other metals, and nonmetallic materials such as plastics, glass and wood, are banging away at our markets. Some of us have learned, the hard way, that for some applications, these materials are potent competitors. We can't afford to underrate them.

While the competitive materials situation is disconcerting for steel, it is true at this time that nothing can replace steel in the majority of its tonnage markets. Availability, superior technical properties, and cost considerations, if sold intelligently and intensively, will prevent any wholesale replacement of steel in the foreseeable future.

But please do not be deluded by this. As we all know, profit success or profit failure in business rests on a razor's edge. This thin margin of victory can readily be shaved away.

Competitive materials have made inroads into steel markets partly because their suppliers have an aggressive promotion and selling philosophy. Frankly, many steel producers haven't had this in meeting the challenge of other materials.

Then there is the basic human trait of identifying what is new with what is good, and what is oid with what is not so good. Some of the major materials which compete with steel are by and large "new" while steel, in the absence of a fresh presentation of its constantly more diversified properties, seems "old"—and this operates against steel products.

We can and we must meet the future with courage and intelligence. One good and forthright step has been the action of the AISI's Board of Directors and Executive Committee in forming the Committee to Promote the Use of Steel. This committee will play an increasing role in steel's battles with other materials.

In the policy role of the Use Committee, there would be appropriate areas like these:

First—collect information on major developments in competing materials so as to define clearly the product and selling challenges posed for the steel industry.

Next—provide broad promotional approaches . . . themes . . . and messages on which member companies can build.

Then—stimulate member companies to undertake effective promotional and other activities to meet the new challenges from materials which compete with steel.

Finally and *very importantly*—utilize the product committees of the Institute to foster the program.

First, member companies must organize—sometimes reorganize—to do this job. It isn't enough just to hold someone in the organization responsible for being *informed* about competitive materials. There must be responsible individuals who are specifically charged with the broad strategy and the detailed tactics to meet this competition.

Individual companies should hit competition from other materials head-on, application by application, and customer by customer.

Finally, steel companies should establish and maintain contact with customers beyond the purchasing agents—with design groups . . . engineering departments . . . research organizations . . . even with the styling studios—in fact everyone who has something to do with the purchase of steel.

This is the best way to sell any material against other materials. It is the route by which other materials are being sold against you. It is the route by which steel must sell itself. Let's take the offensive by better understanding the range of possible properties of our material—by more imaginative product application—greater emphasis on innovation, the better to serve existing and potential markets—by specific, informa-

tive, promotional programs, and by *intensive* and *comprehensive* selling of our services and products.

Another serious aspect of the competition against the steel we produce is imported steel.

Foreign competition is likely to be with us from now on. It may hurt a little less one year than another, but it won't go away like a bad dream and it will make itself felt in more and more steel products. We will be under pressure from more and more foreign producers.

No one with sense thinks that meeting and beating foreign competition is an easy job. It isn't. The foreign product is almost always priced less than the American product, even though an opportunistic price put on it may occasionally be higher than the domestic price, as during the recent strike. *Some day*, wage rates abroad may approach ours—but we should not count on that for years to come.

Having emphasized how tough a problem foreign competition is, let me say just as forcefully that I think we are equal to it.

Let us begin by selling much harder those things that the foreign producer *cannot* offer: service, quality, availability.

First, *metallurgical* service. What foreign producer does anything in this line? Can our customers call up Dusseldorf and have a man sent right out to solve a problem in heat treating, or of sheets that are tearing in the press?

Then, *quality*—the strongest of all possible sales features, and we have it in our domestic steel products. But are we selling it as hard as we can? Have customers grown so accustomed to receiving and working with our quality steels that they simply do not remember how valuable quality and product improvement are to them in terms of high production rates and reduced downtime?

As a general statement, I believe it is a fact that we couldn't sell in the market today most of the exact products we made 15 years ago. And this will be true of today's products 15 years from now. We must face up to this stimulating and challenging fact. And we must have greater insight into what the requirements will be in *another* 15 years.

One factor in these requirements will be the need for higher quality steel as American industry moves to more and more mechanization in producing items made from steel. Why? Because the individual operator on a machine can adjust for minor differences in such qualities as thickness or hardness. But usually the automatic machine cannot cope with these variations.

The third obvious selling weapon against foreign steel is *availability*. Of course, I know the delivery situation earlier this year was loaded with problems. But deliveries from foreign sources take longer and are a lot less certain. I'm not going to belabor this point, but certainly we should not fail to use the availability argument in dealing with customers who show signs of going extensively to foreign steel. The point is this: The need for continuity over an extended period of time is the single most important consideration in the buyer-seller relationship in steel.

Remember: service, quality, availability—our triple line of attack against competition from foreign producers. Notice I have said nothing about tariff protection, because this does not, in my opinion, provide a permanent or basic solution for the problem which confronts us. That problem is competition, and we can meet it only by our being prepared to compete successfully in a society where every individual—and every business enterprise—has the right to choose freely in the market place the product which serves the buyer best.

The way to sell all steel is to sell it as the superior engineering material, which it is. Don't just sell the customer steel. Sell tensile strength. Sell superior hardness. Sell ease of fabrication. Sell tremendous impact resistance. Sell corrosion resistance. Sell hardenability. And to the designer, sell beauty. Sell all these qualities which are so low in cost and in those places where they really count.

Sell an engineering function, not just some pounds of steel, and sell the customer the *profit he makes* with your material.

Our economy has always moved in the direction of technical and engineering advancement. Many developments are just now coming to mass market fruition. These range all the way from metal curtain wall construction for buildings, to startling developments in thermoelectric refrigeration. They open up new outlets for materials. Let's do the things that will make them *markets* for steel.

Am I saying to go out and sell and forget our problems of building more efficient capacity, fighting inflation, finding enough raw materials and improving our industrial relations? Am I saying it is only the salesman who really counts? Obviously the answer is no, for successful selling is the greatest team effort on earth. Every department, every manager and every worker has a part. With employment costs of some $5,000,000,000 annually in steel, there are a lot of people who are staking their livelihoods on the job ahead.

"SPOTLIGHT ON COMMUNICATIONS"

By T. F. PATTON,
President
Republic Steel Corp.
Cleveland, Ohio

IN the early days of the steel industry, communications was a chore that nobody liked, and few people bothered about. Today, communications is not only a need, but an obligation to our stockholders, our employees, our customers and the public at large. It may even be the price of survival of our free enterprise system.

We *must* communicate, because we *must* create broad understanding of business policies and problems. If we fail, we will find ourselves on the defensive in the future even more than we have in the past. Our right to manage will come under even heavier attack, and in effect we will be throwing the American economy open again to the destructive tinkering of the bureaucrat and the exploitation of the labor leader.

Some people feel pessimistic about our chances. I have been told that during the last labor negotiations we did not reach the steelworkers, the public or the

officials in the government; that the 1959 experience was a disastrous defeat for the steel industry. I do not share that pessimism. On the contrary, the events of the the strike convinced me that the steel industry *has* learned how to get the facts to the people—that when we spend the time and the money to build a good program we can create a solid foundation of understanding.

In Republic, for example, we engaged in the most intensive communications effort in our history.

As a result we were not only able to do what we considered to be an effective job in areas in which we had considerable previous experience, but we tackled new media—radio, TV and motion pictures—and came out confident that we were communicating in ways which our employees and the public would make an effort to see or hear, and hopefully, to understand.

Many other companies were equally hard at work, and by our combined efforts we *sold* the facts on inflation, and on the effect of wage pressure in making inflation a threat to the economy. We *sold* the facts on foreign competition, and its effect on jobs and earnings. We sold them so well that we were able to bring the union down to earth in its demands on wages and cost-of-living. We failed only where we failed to communicate, in the complex area of local working conditions—and even there we made notable progress.

In Republic we have worked out a set of Ten Commandments of Communications for Republic management.

1. Communications must be a part of the job of every man on the management team.
2. Seek to improve your communications with your employees every day in the year, not merely when trouble is brewing.
3. Do not underestimate the intelligence of your employees, or their desire to be loyal to the company.
4. Accept your employees' labor union as a fact of life.
5. Seek to understand the fears and aspirations of your employees, for out of understanding comes wisdom in industrial relations.
6. Seek to promote public understanding of your policies and problems, for if you do not you will regret it at bargaining time.
7. Strive to educate your employees and the public in the basic facts of economics and business practice, otherwise your words will fall on barren ground.
8. Communicate in simple language, understandable to all of those to whom your words are directed, otherwise you will be talking to yourself.
9. Do not speak only with words, but with deeds, also; for if your words say one thing and your deeds another your words will not be believed.
10. Listen as well as speak, otherwise you will be talking to yourself and those who already agree with you.

We are beginning to get answers, and as we learn to know our employees better, and devote increased effort to improving their understanding of business policies and practices, the great barrier between employee and manager will narrow. Employees will begin to appreciate the fact that management has harnessed capital, science and engineering to the task of raising steel industry productivity, and that it is rising productivity—not union pressure—that enables companies to pay better wages. They will come to understand, too, that good management—not union pressure—is responsible for the record of improvement in steel industry job security and working conditions. Once they realize these things, peace and cooperation between labor and management becomes a practical goal.

It is going to be a difficult job, but if we do it well we are in sight of the twin goals of labor peace, and a favorable, *dependable*, climate for business growth. ▲

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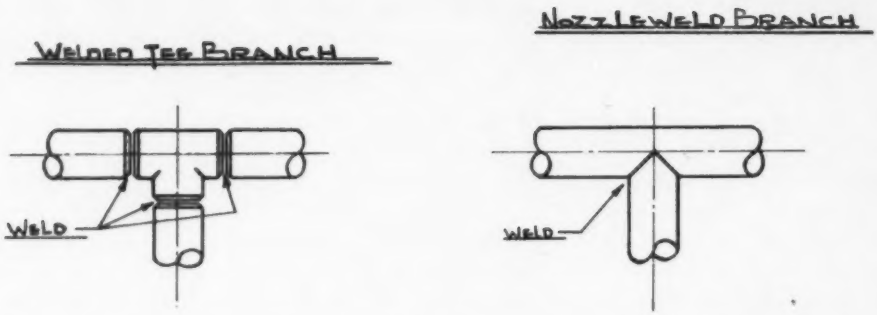

Figure 1 — In nozzle weld design there is less welding and a fitting is also eliminated.

Economy in Pipe Joint Design

by FLOYD P. WOUMANS, Manager Piping Div.,
Auburn & Associates, Inc., Pittsburgh, Pa.

THE use of all welded pipe installation in power plants and steel mills has already become a well established practice. This practice in the steel industry is used almost to the exclusion of other methods for pipe sizes 2½ in. and larger. Welding pipe offers two important advantages; namely, economy in the initial installation and a considerable reduction in the maintenance cost because the elimination of flanged joints practically eliminates leaks. In addition to the normal savings of welded pipe installations, another economy in the initial job can be achieved by the elimination of welding tees and substitution of a miter weld for the branch circuits. The two methods of making a tap or branch connection into a header line are illustrated in Figure 1.

Table I shows the relative cost of using a welding tee branch or nozzle welded branch. An analysis of the statistics of this table are quite interesting and surprising. In the smaller sizes the cost of installation of the nozzle weld branch saves more than half of the cost of a welding tee branch. In the larger sizes the cost of a nozzle weld is one-fifth of the cost of an equivalent welded tee branch.

There are several apparent reasons for the larger savings in the initial installation. First the cost of the welded tee is eliminated and this accounts for a considerable part of the saving. Fittings are always a large part of the cost of material for any pipe installation. Next the cost of making the nozzle weld is half that of welding in a tee. In using a tee, three alinements and three butt welds must be made, all of which contribute to the labor cost. Also, the use of the nozzle weld eliminates the waste of piping associated with the use of the welded tee branch. If the tee is installed near the end of a random length of pipe, the pipe must be cut to exact length with the cutoff end discarded as scrap. With the nozzle weld this waste is eliminated because the branch may be made at any point along the length of the pipe without any short pieces left over. The steel mill engineer accustomed to the use of fittings will automatically insist on the use of a tee.

It is the authors hope that this brief analysis of the comparative cost will prompt the engineers to take advantage of the savings as there is practically no difference in the quality of the job done either way. ▲

TABLE I

Welding Tee Branch: Cost of Handling Including Welds				Nozzleweld Branch: Cost of Alining, Including Welding				
Pipe size, in.	Cost of Welding tee	Cost of (3) welds	Total	Pipe size, in.	Cost of pipe*	Cost of weld	Total	Savings
3	$ 12.80	$ 45.00	$ 57.80	3	$ 0.60	$ 22.50	$ 23.10	$ 34.70
4	17.50	54.00	71.50	4	1.00	27.00	28.00	43.50
6	37.80	72.00	109.80	6	1.83	36.00	37.83	71.97
8	51.70	93.60	145.30	8	3.10	46.80	49.90	95.40
10	102.60	126.00	228.60	10	5.80	63.00	68.80	159.80
12	148.50	143.80	292.30	12	8.78	71.90	80.68	211.62
14	222.70	153.00	375.70	14	10.56	76.50	87.06	288.64
16	270.00	171.00	441.00	16	12.20	85.50	97.70	343.30
18	330.70	185.40	516.10	18	17.35	92.70	110.05	406.05
20	398.25	198.00	596.25	20	18.40	99.00	117.40	478.85
24	513.40	223.20	736.60	24	27.80	111.60	139.40	597.20

* To replace tee.

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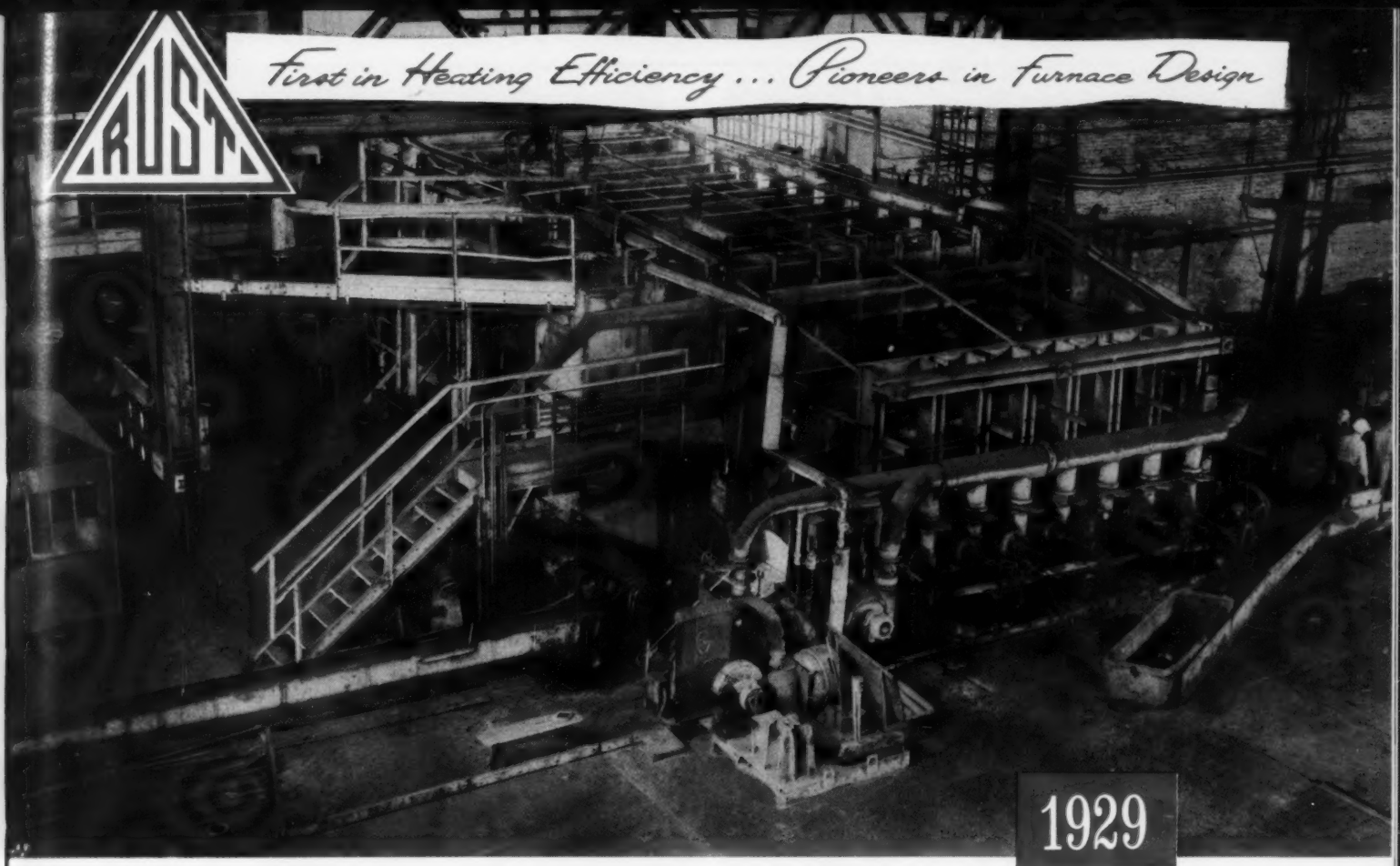

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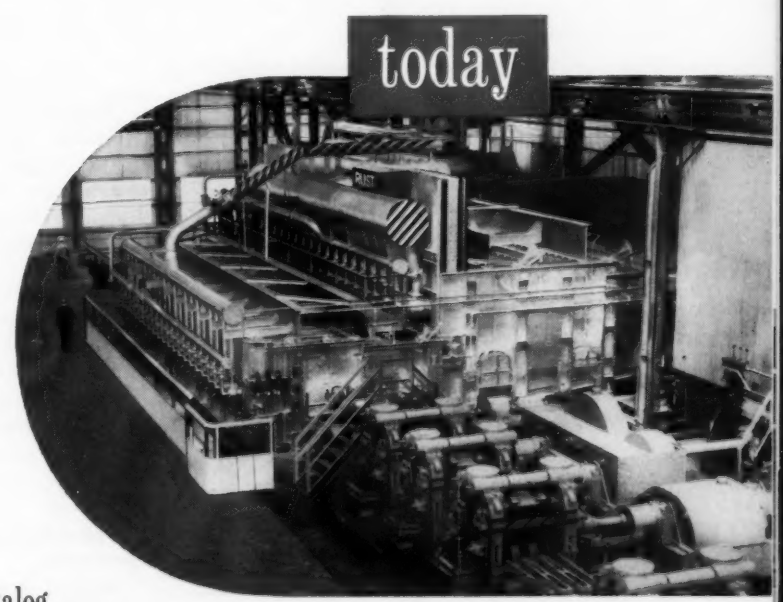

Modern, two-zone, continuous billet furnace at 10" rod mill, Sheffield Division, Armco Steel Corporation.

RUST FURNACE COMPANY

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Another MX Test System at work...

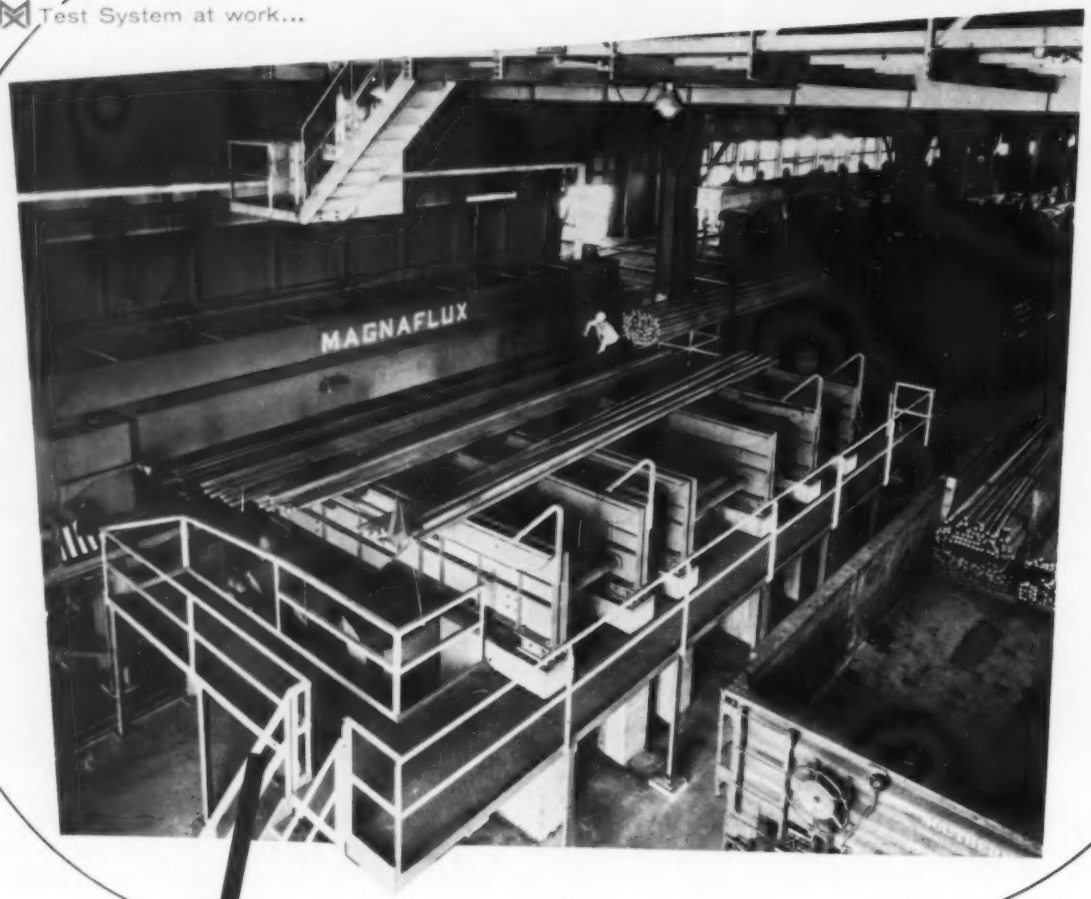

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Figure 1 — The new 38-in. piercing mill is at Timken's Gambrinus plant near Canton, Ohio.

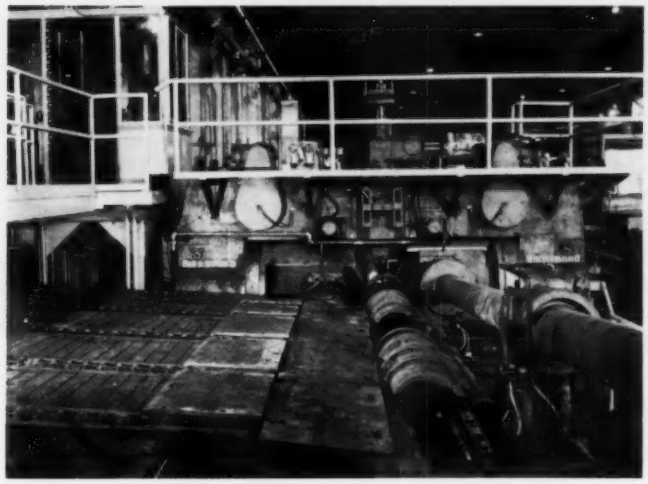


Figure 2 — Inlet side of the piercing mill.

Timken Installs 38-In. Piercing Mill at Gambrinus Plant

INSTALLATION of a new piercing mill has been completed for the No. 3 Tube Mill at the Timken Roller Bearing Co.'s Gambrinus steel mill near Canton, Ohio. It replaces a 36-in. piercing mill which is to be reconditioned for installation and use in the company's new No. 4 Tube Mill being constructed at the Gambrinus plant.

The new 38-in. mill will improve concentricity of seamless steel tubes, especially in larger tube sizes from 9 to 12 in. in diameter. Size range on the new mill will run from 4½ to 12-in. steel diameter with maximum billet size up to 15 ft in length or a maximum of 3500 lb. The 36-in. mill had a maximum size of 10 in.

Production capacity of the new mill averages 10,000 tons per month.

Installation of the 38-in. mill began in May and was recently completed at a cost of approximately $1,000,000. The mill offers the added advantage of a more modern layout which is capable of improving the quality of pierced tubes at extreme sizes.

The standard work force on the new mill totals 111 employees. Seventy-five members of this force are operating men and thirty-six are auxiliary personnel.

The No. 4 Tube Mill is expected to begin operation in July of 1961. With both mills producing, the Timken Co. will have greatly increased capacity and still further improved concentricity of its seamless steel tubing.

Tubing manufactured by the company is sold to steel customers and is used by the company in the manufacture of Timken tapered roller bearings. ▲

TC&I to Install Six-Stand Tandem Mill

A MAJOR step in a broad modernization program at the Fairfield Tin Mill of United States Steel's Tennessee Coal & Iron Division will soon get underway with the installation of a new six-stand 52-in. cold reduction mill at that plant. When completed, this will be U. S. Steel's first six-stand cold reduction mill for tinplate.

The six-stand mill will replace two 5-stand mills that have been in use in the tin mill since that plant was completed in 1938, and will have a speed of approximately three times that of the existing facilities. It will be capable of cold reducing steel for tinplate at speeds over 6600 fpm.

The new six-stand cold reduction mill is expected to be placed in operation during the early part of 1962.

Other major modernization projects at the tin mill include:

1. A continuous annealing line (heat treatment). This line is replacing box annealing equipment.

2. A 54-in. pickling line (descaling process). This pickling line replaces two lines and incorporates the most modern facilities to produce quality tinplate products and to process wider materials thus helping to meet the growing demand for wider, lighter tinplate.

3. A modern 56-in. high-speed, heavy-duty temper mill will provide improved flatness and temper of tinplate products.

Both the continuous annealing line and pickling line are expected to be completed and in operation by the latter part of this year.

Coupled with the addition of the cold reduction facilities at the tin mill are expanded annealing facilities at the Fairfield sheet mill. This phase of the modernization program, using the most modern techniques available, will enable TCI to produce improved surface conditions on sheet products and to provide quicker delivery service to customers. ▲

J&L Starts Operation Of Lind-Greenway Mine

JONES & Laughlin Steel Corp. has put into operation a Minnesota iron ore mine which should be an active producer of high-quality beneficiated ore for many years. The mine, which is known as the Lind-Greenway Mine, is expected to produce about 700,000 gross tons of high grade beneficiated ore per year, or about 10 per cent of J&L's current blast furnace requirements. It is expected that this rate of production can be maintained for many years.

The mine is located on the extreme west end of the Mesabi Range near Grand Rapids. It is being operated as a part of J&L's Minnesota Ore Division, which also operates pits near the communities of Calumet, Hibbing, Virginia, and Gilbert, Minn. Headquarters for the Division is at Virginia.

Operation of the mine is novel in that it consists of two separate open pits, one on each side of Minnesota's Prairie River. The pits are connected by a truck haulage bridge.

The crude ore is being mined by conventional power shovel methods, and hauled by heavy-duty trucks to a concentrator. This is similar to methods employed at J&L's other Minnesota mining properties. It then is washed before shipment. Ultimately, facilities for heavy media treatment will be added as leaner ores are encountered.

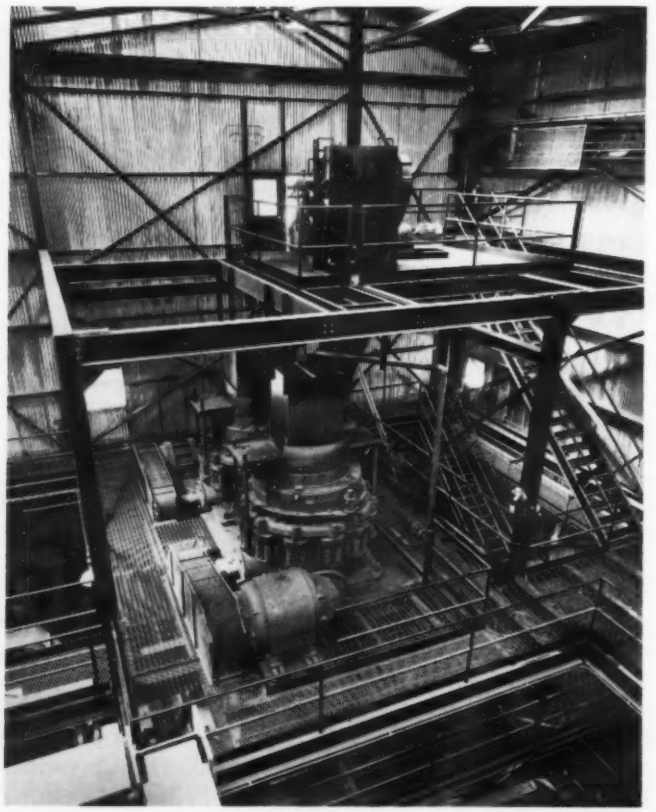
Shipment is by rail and ore boat to J&L's three steel-producing plants at Pittsburgh and Aliquippa Pa., and Cleveland, Ohio.

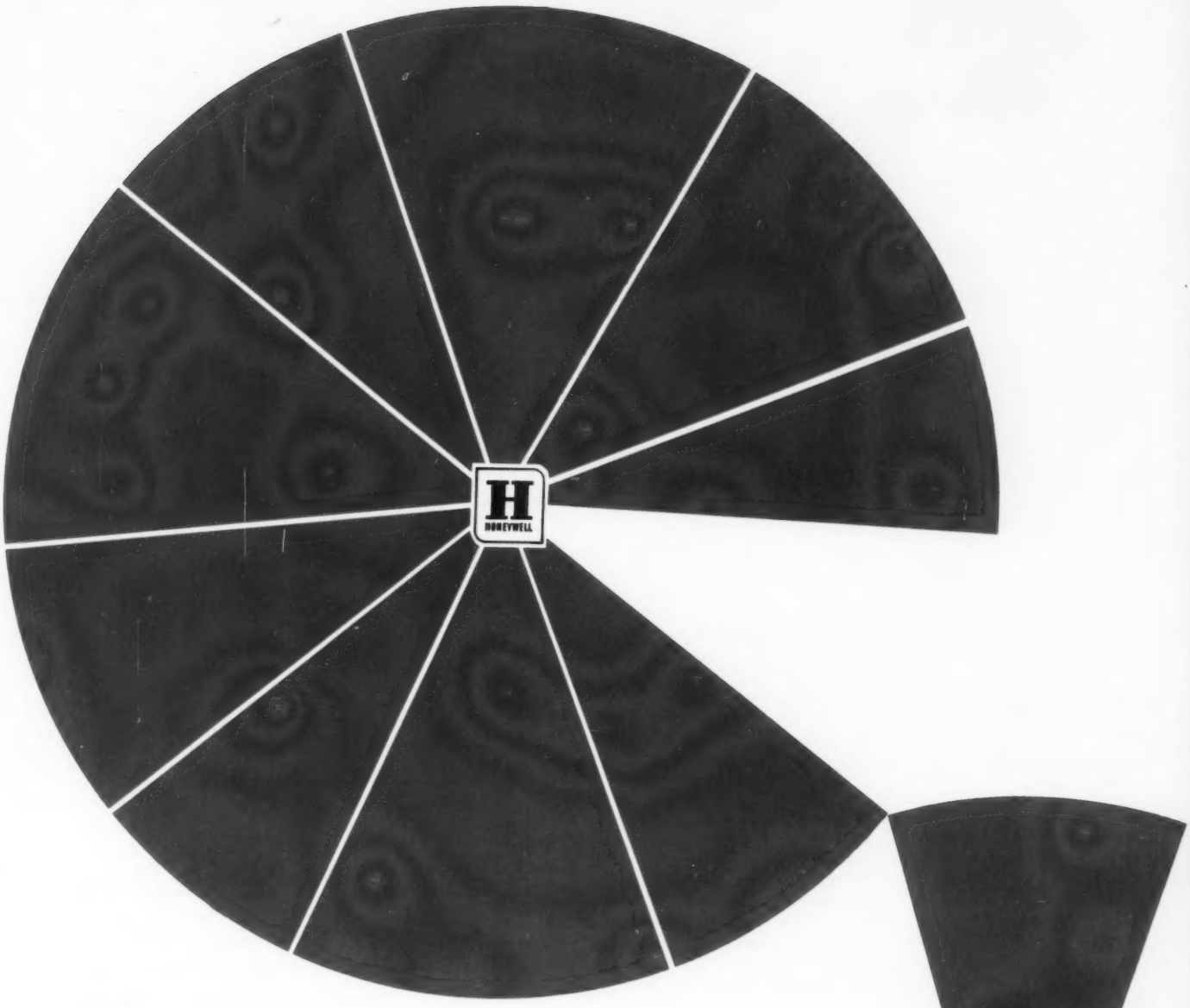
The mine employs about 80 men. About 200 men will be employed when full production is reached. Most of these employees are being transferred from other J&L mining properties in Minnesota.

J&L obtained a lease for the Lind portion of the property in 1913. The Greenway portion of the property, which had been operated during World War II by another concern, was obtained by J&L in 1948. In addition to its mines in Minnesota, J&L also operates iron ore mining divisions in Michigan and New York. ▲

Figure 1 — Beneficiated iron ore for Jones & Laughlin Steel Corp.'s blast furnaces is moved on conveyor belts to railroad cars at the new Lind-Greenway Mine, a 700,000-gross ton a year operation.

Figure 2 — At the Lind-Greenway Mine, there are two cone crushers, each capable of crushing 100 tons of ore per hour to 1¼ in. size.



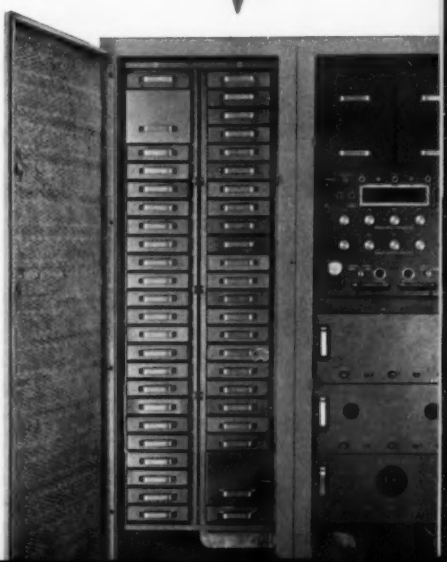


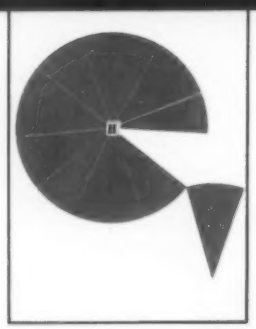
NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HEART OF THE FIRST COMPLETELY INTEGRATED COMPUTER CONTROL SYSTEM

Now, with the new Honeywell 290 computer control system, you can control an industrial process or even an entire plant, fully automatically. It is the first complete control system—everything from process variable transmitter to computer to final control elements—available from any one manufacturer. Heart of the system is the new Honeywell 290 industrial digital computer.

The Honeywell 290 is the most powerful computer in its class, despite its small size, low cost and low power consumption. It performs, for example, 8,000 additions, 1,250 multiplications or 400 square root extractions per second. Unique, powerful macro-instructions help make the 290 easy to program, reduce working memory requirements and increase operating speeds. These special instructions augment the basic instructions, and eliminate many special subroutines.

The combination of high-speed operation and the reliability of conservative solid-state circuitry brings optimum control of many types of industrial processes. In addition, the Honeywell computer control system can compile complex operating guides, correlate data, and reduce huge masses of acquired data into immediately usable information for monitoring or optimizing process operations.





NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HIGH SPEED, PARALLEL OPERATION, EASILY PROGRAMMED

The high computation speed of the Honeywell 290 provides many advantages in on-line monitoring and control of industrial processes:

- Higher sampling rates give closer control because each variable can be checked more frequently.
- More work can be accomplished in a given time.
- Checking and validity routines can be used extensively.
- Tasks other than process control can be accomplished either through time-sharing or through priority instructions in the computer program.

The Honeywell 290 is the first industrial digital computer to use parallel operation within the computer. All digits in a multi-digit number are transferred *simultaneously* from one element to another within the computer . . . in one count of the clock. Therefore a much slower clock rate can be used. Components are operated far below their maximum ratings—greatly increasing overall reliability, while permitting many thousands of program steps to be executed each second.

The computer combines both magnetic core and drum memory. Main memory is the magnetic core type, and it can be supplied with capacities of 1,024, 2,048 or 4,096 words. A magnetic drum memory with a capacity of either 4,096 or 8,192 words is also provided—a total capacity of 12,288 words. This combination gives you the speed and random accessibility of core memory with the program permanence of drum memory.

The Honeywell 290 Computer operates with standard, field-proved Honeywell process instrumentation in a completely integrated system of control. *ElectriK Tel-O-Set* transmitters feed process variable input data to the computer. These solid-state, two-wire transmitters convert temperature, pressure, flow and other measurements into electric signals. Various types of computer peripheral equipment are supplied by Honeywell to add flexibility to the system and make it easily expandable to meet future requirements. This equipment includes analog-to-digital and digital-to-analog converters, high-speed paper tape readers and punches, visual displays and electric typewriters. Honeywell *ElectriK Tel-O-Set* transducers make the computer completely compatible with existing pneumatic process measuring and control instruments.

Get complete details from your nearby Honeywell field engineer. Or write for Catalog C-290. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

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Honeywell

First in Control

SINCE 1885

FALK All-Motor Motoreducers driving pipe conveyors in seamless tube mill.

Photo courtesy of
The Colorado Fuel and Iron Corporation

You get these "extras" when you buy FALK *all-steel* Motoreducers

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2. **Inherently stronger gear teeth.** By AGMA standards, Falk extra-depth, high pressure angle helical gears are inherently stronger than ordinary helical teeth, thus assuring reliable operation and longer gear life.
3. **Highest known gear efficiency**—98½% per gear mesh under full load! This means maximum productive work for your power dollar.
4. **Longer service life**...advanced FALK design makes it possible to machine both bores for each shaft assembly at one time, thus eliminating possible accumulation of tolerances that occurs when individually machined parts are assembled. The result—better alignment of revolving elements that permits units to transmit rated capacity longer.
5. **Standard units to fit your needs.** Integral and All-Motor® Motoreducers are available in horizontal, vertical and right angle types...a type for every use.

Units are available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Prompt delivery from factory, warehouse or distributor stocks.
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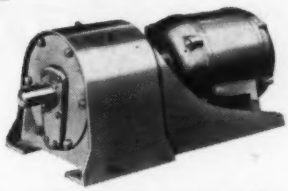
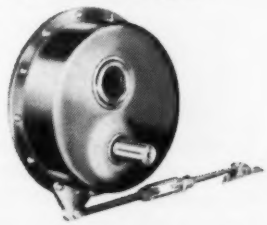


THE FALK ALL-MOTOR® MOTOREDUCER
the original All-Motor unit

(Shown) Horizontal concentric model. Also available in right angle and vertical types.



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Proved best for the countless industrial applications where a reducing unit mounting directly on shaft of the driven machine is indicated.

Units from 1/2 to 50 hp. Ratios —4:1, 14:1 or 24:1. Torque capacity up to 41,000 lb-in (in standard units). Prompt shipment from stock. For details, ask for ***Bulletin 7100.***

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Date-line Diary...

July 1

Δ American Iron Ore Assn. and AISI joint reports show receipts of iron ore in the United States for May, 1960, amounted to 15,925,648 gross tons, compared with 16,049,208 tons in May, 1959. Consumption for May, 1960, totaled 55,154,737 gross tons, compared with 54,438,641 gross tons in May, 1959. Blast furnaces in operation on May 31, 1960, totaled 173 of the existing 258. On May 31, 1959, 227 blast furnaces were in operation.

Δ The Bureau of the Census report shows that shipments of nonferrous castings in April, 1960, totaled 180,083,000 lb, compared with 212,837,000 lb in March, 1960.

Δ The Bureau of the Census reports that shipments of iron and steel castings in April, 1960, totaled 1,249,847 short tons compared with 1,373,348 short tons in March, 1960, and 1,471,020 tons in April, 1959.

July 4

Δ The AISI reports that the operating rate of the steel industry for the week of July 4 is scheduled at 1,218,000 tons (42.7 per cent of capacity). This compares with 1,510,000 tons one week ago (53.0 per cent capacity) and 2,252,000 tons one year ago. Index of production for the week is 75.8.

July 5

Δ The American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes for the months of June, 1960, totaled 12,038,328 gross tons, compared with 12,987,302 gross tons in June, 1959.

Δ Auto production in July, 1960, is estimated to be 460,000 cars, down from the June, 1960, total of 613,100 cars and 555,000 cars in July, 1959.

Δ Agricultural Secretary Benson announced that U. S. farm exports approached $4,600,000,000 in the year ended June 30, 1960, compared with $3,700,000,000 in the previous fiscal year.

Δ Bureau of Mines reports that production of Pennsylvania anthracite for June, 1960, amounted to 1,441,000 net tons compared with 1,262,000 tons in May, 1960, and 1,777,000 tons in June, 1959.

July 6

Δ The AISI reported that shipments of finished steel products from mills during May, 1960, totaled 6,272,432 net tons, compared with 6,700,000 tons in April, 1960, and 8,700,000 tons in May, 1959.

July 7

Δ President Eisenhower cut sugar deliveries to the U. S. from Cuba to 39,752 tons for the remainder of 1960, a reduction of 700,000 tons.

Δ National production of goods and services ran at an annual rate of $503,000,000,000 in the second quarter of 1960, an increase of $3,000,000,000 over the pace during the first quarter of 1960.

Δ The Bureau of the Census reports that production of titanium mill products in May, 1960, totaled 810,464 lb compared with 534,742 lb in April, 1960, and 753,576 lb in May, 1959. Shipments were equal to production.

July 8

Δ Auto sales in June, 1960, totaled 593,800 cars, less than one per cent over May, 1960 and 2.3 per cent over June, 1959.

Δ Pacific States Steel Corp. announced it has borrowed $3,600,000 to complete construction of a blast furnace and rolling mill at Union City, Calif. Completion of the rolling mill is predicted in about six months; the blast furnace in about 18 months.

July 11

Δ The Commerce Dept. reported steel exports in May, 1960, rose to 320,000 tons, an increase of 85,000 tons over the April, 1960, total. Imports totaled 272,000 tons in May, 1960, down 59,000 from the April, 1960, imports.

Δ The U. S. Dept. of the Interior, Bureau of Mines, reports that production of Pennsylvania anthracite in 1959 totaled 20,649,286 net tons compared with 21,171,142 net tons in 1958; value at breaker, washery, or dredge in 1959 was $172,319,913, in 1958 was $187,898,316.

Δ The AISI reports that the operating rate of the steel industry for the week of July 11 is scheduled at 1,513,000 tons (53.1 per cent of capacity). This compares with 1,203,000 tons one week ago (42.2 per cent capacity) and 1,097,000 tons one year ago. Index of production for the week is 94.2.

July 12

Δ Major steel companies have cut prices about two per cent on pipe sold to jobbers by increasing the standard discount.

Δ Zinc producers trimmed prices ¼¢ a lb on special high grade zinc and by 0.15¢ a lb on regular high grade zinc.

Δ The AISI reports that production of steel for ingots and castings in June, 1960, totaled 7,394,000 net tons, compared with 8,830,472 tons in May, 1960, and 10,907,634 tons in June, 1959. Production for the first half of 1960 totaled 60,743,222 tons compared with 64,278,203 tons in the first six months of 1959.

July 13

Δ U. S. Steel's Pittsburgh Steamship Co. Div., has reduced its operating fleet to 40 of its 53 vessels; Canada Steamship Lines, Montreal, reports six of its 17 ore ships are idle.

Δ The Labor Dept. reports that unemployment in June, 1960, totaled 4,400,000, up 964,000 over the May, 1960, level. Total employment in June, 1960, amounted to a record 68,600,000.

July 14

Δ Pittsburgh Steel Co. accepted a report from a joint labor-management study committee recommending a specific method for cutting incentive pay scales. The action left it up to the USW locals affected to take the pay reductions or reject the report.

Δ The Bureau of the Census reports that shipments of aluminum pig and ingot in May, 1960, totaled 127,156,000, compared with 119,023,000 lb in April, 1960, and 130,772,000 lb in May, 1959; shipments of aluminum mill products in May, 1960, amounted to 271,887,000 lb compared with 247,382,000 lb in April, 1960, and 321,350,000 lb in May, 1959.

July 15

Δ General Electric Co. reported for the first six

months of 1960 sales totaling $2,022,699,000, earnings amounting to $111,429,000 or $1.26 per share compared with sales totaling $2,065,447,000, earnings amounting to $117,239,000 or $1.34 per share for the same period of 1959.

Δ The Commerce Dept. reported that corporate profits before taxes for the first quarter of 1960 ran at a seasonally adjusted annual rate of $48,800,000,000, 9 per cent above the fourth quarter of 1959, and 5 per cent over the first quarter of 1959.

Δ Westinghouse Electric Corp. reported for the first half of 1960 total sales of $953,884,000, net earnings of $40,454,000 or $1.14 per share compared with sales totaling $914,204,000, earnings of $34,150,000 or 96¢ a share for the same period of 1959.

July 18

Δ Great Northern and Northern Pacific directors voted to consolidate the two roads. The new network would include the Burlington Railroad, and the Spokane Railway. Each shareholder of both railroads would receive one share of the merged road for each share held and Great Northern shareholders would receive, in addition, one-half share of 5½ per cent preferred stock of $10 par value.

Δ The AISI reports that the operating rate of the steel industry for the week of July 18 is scheduled at 1,556,000 tons (54.6 per cent of capacity). This compares with 1,476,000 tons one week ago (51.8 per cent capacity) and 365,000 tons one year ago. Index of production for the week is 96.9.

Δ Shipments of iron and steel castings during 1959 totaled 14,631,028 short tons compared with 12,139,154 tons in 1958 according to Bureau of the Census.

Δ The Bureau of the Census reports that pig iron production in the U. S. in 1959 totaled 60,210,257 short tons, compared with 57,154,909 tons in 1958. Consumption of scrap in the U. S. in 1959 totaled 66,061,516 short tons and consumption of pig iron equaled 61,773,191 short tons compared with consumption in 1958 totaling 56,359,935 tons scrap and 57,262,336 tons of pig iron.

Δ Shipments of nonferrous castings during 1959 totaled 2,337,610,000 lb compared with 1,952,487,000 lb shipped in 1958.

July 19

Δ The Commerce Dept. reported that personal income in June rose to $405,800,000,000 annually, $1,100,000,000 over the May, 1959, rate.

Δ The Japan Iron & Steel Federation reports that pig iron production in Japan in May, 1960, amounted to 1,093,000 net tons; production of ingot steel equaled 2,019,000 net tons.

July 20

Δ The Agriculture Dept. reported that net farm income, after expenses, for the second quarter of 1960, ran at $11,800,000,000 annually or $1,600,000,000 above the first quarter pace.

July 21

Δ President Eisenhower announced a surplus of $1,100,000,000 for the fiscal year ending June 30, 1960.

Δ Resistance Welder Mfrs. Assn. reported that shipments of resistance welding equipment for June, 1960, rose to $3,250,000, approximately 41 per cent over the May, 1960, total; bookings in June, 1960, totaled nearly $2,250,000, an increase of 18 per cent over May, 1960, new orders.

July 22

Δ The Aluminum Assn. reports that production of primary aluminum in June, 1960, totaled 171,356 short tons compared with 175,863 tons in May, 1960. Shipments in the second quarter totaled 515,815 short tons compared with 491,538 tons in the first quarter of 1960, and 486,393 tons in the second quarter of 1959.

Δ The Census Bureau reported that private housing starts in June, 1960, ran at a seasonally adjusted annual rate of 1,334,000, compared with rate of 1,336,000 in May, 1960.

Δ The ARCI reported that deliveries of new freight cars in June, 1960, totaled 6042 compared with 5931 in May, 1960, and 3950 in June, 1959. New orders in June, 1960, amounted to 321 compared with 2234 in May, 1960, and 8054 in June, 1959. Backlog of cars on order as of July 1, 1960, totaled 29,535 compared with 36,106 on June 1, 1960, and 40,973 on July 1, 1959.

Δ The Bureau of Mines reported that consumption of scrap in May, 1960, totaled 5,051,000 gross tons compared with 5,625,717 tons in April, 1960. Consumption of pig iron totaled 5,467,000 gross tons in May, 1960, compared with 5,853,330 tons in April, 1960. Consumers stocks on hand were 8,460,000 gross tons of scrap and 3,158,000 tons of pig iron.

Δ Allis-Chalmers Manufacturing Co. reports for the first six months of 1960 sales totaling $282,691,100, net earnings amounting to $7,780,145 or 83¢ a common share compared with sales totaling $221,226,490, net earnings amounting to $5,314,739 or 57¢ a share.

July 25

Δ Government figures show that the nation's production of goods and services in the second quarter of 1960 amounted to a seasonally adjusted annual rate of $505,000,000,000, less than 1 per cent over the rate of the first quarter, 1960.

Δ The National Machine Tool Builders Assn. reports that new orders of metal cutting and metal forming type machine tools in June, 1960, totaled $55,000,000 compared with $49,950,000 in May, 1960. Shipments totaled $64,250,000 in June, 1960, compared with $56,350,000 in May, 1960.

Δ The AISI reports that the operating rate of the steel industry for the week of July 25 is scheduled at 1,533,000 tons (53.8 per cent of capacity). This compares with 1,550,000 tons one week ago (54.4 per cent capacity) and 345,000 tons one year ago. Index of production for the week is 95.4.

July 26

Δ The Bureau of the Census reports that shipments of nonferrous castings in May, 1960, totaled 181,307,000 lb compared with 180,083,000 lb in April, 1960.

Δ The Bureau of the Census reported that shipments of iron and steel castings for March, 1960, totaled 1,373,346 short tons compared with 1,320,098 tons in February, 1960, and 1,420,080 tons in March, 1959.

July 27

Δ Pittsburgh Steel Co. notified USW that existing incentive wage scales will be discontinued. Half the excess over 50 per cent of base pay will be taken away the first year and the remainder will be discontinued the second year.

Δ The Bureau of the Census reported that shipments of iron and steel castings for May, 1960, totaled 1,247,904 short tons compared with 1,249,847 tons in April, 1960, and 1,453,937 tons in May, 1959.

July 28

Δ F. W. Dodge Corp. reports that construction contracts in the United States in June, 1960, amounted

STEEL COMPANIES QUARTERLY FINANCIAL REPORTS

	Period	1960 Net Sales	1960 Net Profits	1960 Earnings per share	1959 Net Sales	1959 Net Profits	1959 Earnings per share
Acme Steel Co.	2nd quar.	35,774,772	528,394	$0.15	$ 49,671,140	$ 2,592,125	$0.91
	1st half	82,626,119	2,620,916	0.87	89,780,715	4,517,618	1.58
Alan Wood Steel Co.	2nd quar.	16,800,742	350,150	0.42	20,908,681	1,141,057	1.55
	1st half	37,043,281	1,205,145	1.56	39,376,756	2,096,321	2.84
Allegheny Ludlum Steel Corp.	2nd quar.	55,725,943	741,000	0.19	92,721,935	7,819,467	2.02
	1st half	135,398,561	5,532,584	1.43	162,998,022	12,369,009	3.20
Armco Steel Corp.	2nd quar.	253,342,057	17,775,225	1.20	338,349,251	29,441,030	1.99
	1st half	533,142,531	41,733,219	2.82	601,066,434	50,593,068	3.42
Atlas Steels, Ltd.	2nd quar.	...	737,000	0.68	...	800,000	0.74
	1st half	...	1,700,000	1.56	...	1,760,144	1.62
Bethlehem Steel Co.	2nd quar.	569,031,374	29,714,308	0.62	832,216,538	73,591,528	1.59
	1st half	1,224,852,388	81,543,035	1.72	1,448,146,118	123,158,829	2.64
Ceco Steel Products	2nd quar.	19,567,981	405,408	0.40	22,553,491	808,639	0.81
	1st half	34,408,708	523,332	0.52	38,261,415	1,052,151	1.05
Colorado Fuel & Iron Corp.	2nd quar.	...	(432,260)*	...	...	7,983,920	2.23
	1st half	...	2,414,432	0.56	...	12,588,760	3.51
Continental Steel Corp.	2nd quar.	12,692,218	1,173,228	1.14	17,386,077	1,707,426	1.65
	1st half	25,910,482	2,308,642	2.24	30,318,606	2,788,457	2.70
Copperweld Steel Co.	2nd quar.	32,803,302	864,344	0.74	41,078,041	1,996,543	1.76
	1st half	68,943,844	2,253,518	1.92	74,554,175	3,497,798	3.08
Crucible Steel Corp. of America	2nd quar.	53,034,433	309,345	0.05	88,083,827	5,109,855	1.31
	1st half	124,668,352	3,034,143	0.72	154,566,957	8,621,061	2.22
Detroit Steel Corp.	2nd quar.	21,132,118	667,858	0.17	33,210,859	3,175,354	0.82
	1st half	55,804,036	4,207,465	1.08	57,161,286	5,793,035	1.49
Eastern Stainless Steel Corp.	2nd quar.	16,279,149	1,446,331	0.31	20,288,421	950,137	0.66
	1st half	34,634,706	1,225,666	0.85	36,479,196	1,629,356	1.13
Edgewater Steel Co.	1st half	8,434,200	284,920	1.52	9,631,496	564,235	3.01
Firth Sterling, Inc.	3rd quar.	5,990,300	(47,600)	...	6,300,300	135,200	0.08
	9 mo.	18,082,700	(208,400)	...	15,892,500	23,100	...
Granite City Steel Co.	2nd quar.	38,065,385	3,316,896	0.77	47,634,634	4,885,563	1.14
	1st half	81,489,041	7,637,551	1.78	85,173,398	8,370,326	1.95
Green River Steel Co.	2nd quar.	...	(113,512)	...	...	264,964	...
	1st half	...	298,514	...	...	441,054	...
Inland Steel Co.	2nd quar.	204,524,143	14,323,569	0.82	257,289,594	24,313,291	1.40
	1st half	432,089,962	33,067,503	1.89	469,205,401	42,172,381	2.43
Interlake Iron Corp.	1st half	51,836,476	3,467,140	1.54	70,317,680	5,588,190	2.49
Jessop Steel Co.	2nd quar.	7,997,192	193,527	0.30	9,393,872	515,285	0.86
	1st half	18,411,879	741,262	1.15	15,519,513	973,177	1.63
Jones & Laughlin Steel Corp.	2nd quar.	207,164,000	8,342,000	1.02	316,384,000	26,468,000	3.34
	1st half	461,588,000	26,136,000	3.24	552,768,000	42,206,000	5.31
Kaiser Steel Corp.	2nd quar.	53,674,847	188,264	(0.19)	86,234,844	6,895,020	1.85
	1st half	118,661,952	6,874,924	1.60	147,264,817	10,197,707	2.61
Keystone Steel & Wire	year	128,840,899	8,320,490	4.44	120,071,295	9,075,374	4.84
Latrobe Steel Co.	1st half	14,140,857	937,072	0.83	...	1,275,925	1.13
Lukens Steel Co.	2nd quar.	24,312,372	962,465	1.01	27,734,792	2,063,191	2.16
	1st half ending June 18	54,729,261	3,276,907	3.44	48,184,123	3,071,585	3.22
McLouth Steel Corp.	2nd quar.	...	3,848,333	1.05	...	5,745,105	1.58
	1st half	...	9,675,307	2.67	...	10,657,133	2.93
National Steel Corp.	2nd quar.	174,406,640	9,583,019	1.26	241,070,420	22,957,018	3.06
	1st half	394,248,812	27,301,361	3.61	438,730,125	39,461,108	5.26
Phoenix Steel Corp.	2nd quar.	7,638,000	(283,000)	...	16,918,002	375,379	0.35
	1st half	24,840,000	(159,000)	...	25,910,128	490,000	0.46
Pittsburgh Steel Co.	2nd quar.	37,229,628	237,617	(0.06)	62,436,201	2,670,903	1.48
	1st half	87,853,474	2,405,194	1.10	113,734,377	4,041,518	2.14
Republic Steel Corp.	2nd quar.	263,335,991	13,168,938	0.84	463,219,072	40,245,132	2.57
	1st half	637,322,904	41,408,483	2.64	784,655,207	67,089,717	4.28
Sharon Steel Corp.	2nd quar.	25,137,240	65,364	0.06	48,866,113	2,480,052	2.24
	1st half	72,885,400	2,306,841	2.09	83,574,710	3,070,905	2.78
United States Steel Corp.	2nd quar.	1,002,393,088	80,893,489	1.38	1,448,743,088	148,363,193	2.64
	1st half	2,189,948,509	193,472,241	3.35	2,526,331,380	254,948,496	4.50
Universal-Cyclops Steel Corp.	2nd quar.	28,261,286	1,034,832	0.55	37,557,816	3,228,688	1.72
	1st half	64,561,420	3,120,826	1.66	67,234,053	5,309,180	2.82
Wheeling Steel Corp.	2nd quar.	60,656,000	2,609,000	1.04	89,757,000	6,540,000	2.91
	1st half	137,778,000	8,156,000	3.47	156,319,000	11,011,000	4.84
Woodward Iron Co.	1st half	...	2,577,338	1.01	...	2,911,938	1.13
Youngstown Sheet and Tube Co.	2nd quar.	152,377,231	5,997,762	1.72	244,274,952	17,162,941	4.94
	1st half	350,403,635	18,889,010	5.42	428,763,360	28,704,805	8.27

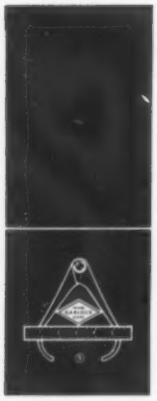
* Items in parentheses are losses.

to $3,472,276,000 compared with $3,659,017,000 in June, 1959. The index (1947–1949 = 100) for June, 1960, is 272, for May, 244, and for June, 1959, 288.

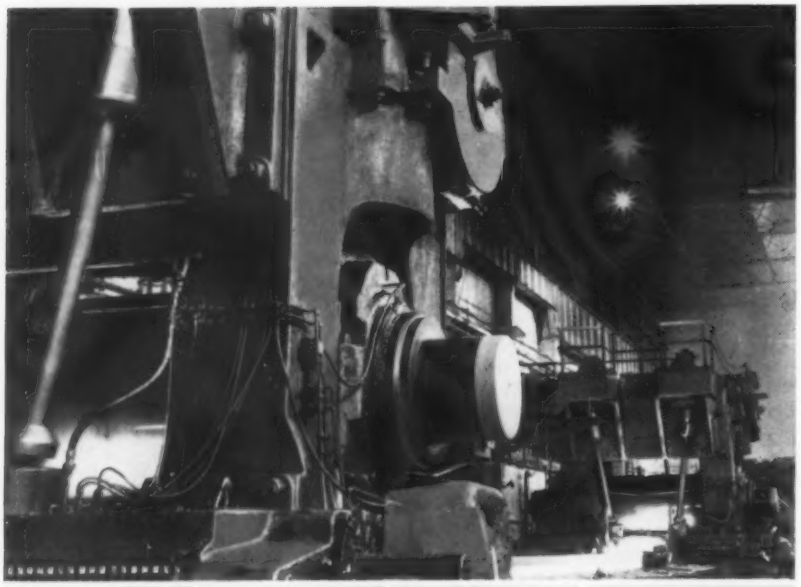
Δ National Machine Tool Builders Assn. reports that shipments of metal cutting type machine tools totaled $265,900,000 during the first six months of 1960 up 41 per cent over the 1959 total.

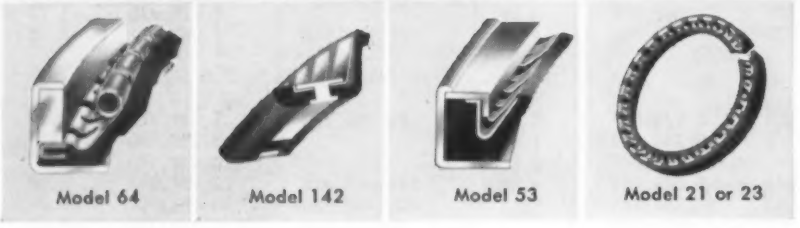
July 30

Δ The Aluminum Assn. reports that shipments of aluminum sheet and plate in June, 1960, totaled 127,071,000 lb, compared with 122,789,000 lb in May, 1960. Shipments of aluminum foil in June, 1960, totaled 18,894,474 lb compared with 18,414,061 lb in May, 1960.



ENGINEERED OIL SEALS for Steel Mills





Model 64 | Model 142 | Model 53 | Model 21 or 23

FULL BEARING PROTECTION IN SEVEREST ATMOSPHERES

Everywhere in steel—on hot and cold strip mills, blooming and structural mills—Garlock KLOZURE* Oil Seals prevent leakage of vital bearing lubrication. And they further prevent damage to the bearings by sealing out scale, spray, dirt, and other foreign matter.

For example, Model 142, a face-type KLOZURE, is designed to seal surfaces perpendicular to shaft . . . keeps water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 are applied to large shafts at normal or high speeds . . . ideal for protecting bearings on back-up and work rolls. Model 53 withstands temperatures up to 250°F at normal or high speeds . . . recommended for table rolls. Where equipment can't be dismantled easily, Models 21 or 23 Split-KLOZURES are the choice.

All KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

Sealing Element, case, spring, and adapter on KLOZURES are designed for peak efficiency and durability. Garlock, with 70 years' experience and modern production facilities, manufactures KLOZURE Oil Seals in proper design and to extremely accurate dimensions from materials which are best suited for your application. Engineering skill, vast experience, and mass production know-how bring you the finest oil and grease seals available.

Obtain more information by calling the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

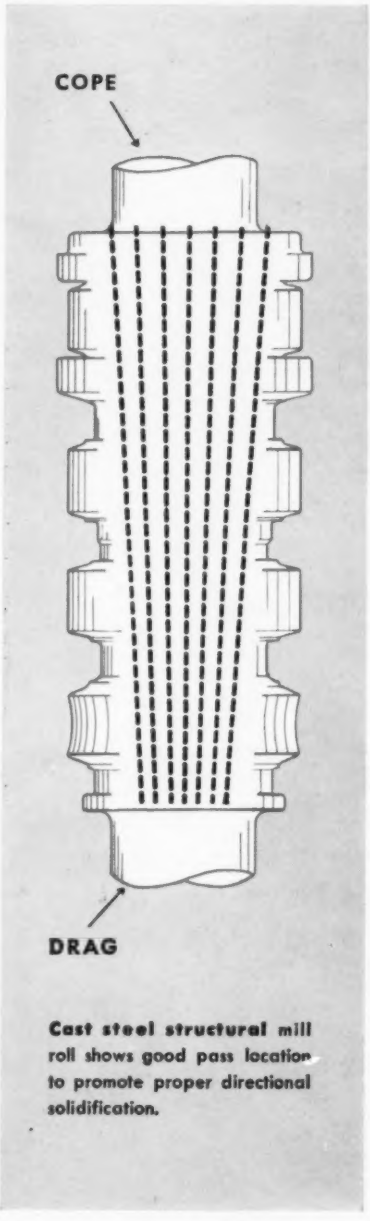
*Registered trademark

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

With rolls, it pays to know which end is "up"



Cast steel structural mill roll shows good pass location to promote proper directional solidification.

There's a very good reason why every roll shipped by Mack-Hemp carries the word "DRAG" engraved on one wabbler. With all cast rolls, maximum strength and depth of sound metal tend to occur toward the *drag* end of the roll—the end at the bottom of the mold when the roll is being poured. This is because of the normal manner in which the "lines of solidification" form as the molten metal cools and solidifies. Also the pressure from the weight of the metal above helps increase the density of the metal in the drag end of the roll.

As you can see from the diagram at the left, the solidification lines angle gently outward as they rise toward the top or "cope" neck of the roll, forming a cone-shaped pattern. In general, these lines of solidification mark the boundary of the dense, homogeneous metal. As a result, there is more good metal in and near the drag end than at the cope end. To assist the roll user in quickly identifying the "bottom" end of his rolls, Mack-Hemp brands the drag wabbler of every roll produced in its foundries.

Locate the deepest passes in the DRAG end—Roll designers making drawings for blooming, rail and structural mill rolls should try to locate the deepest passes in the driven end of the roll, as illustrated. Directional solidification from drag to cope is then more easily accomplished and a sounder casting results.

We don't mean to imply that deep passes cannot be located at the cope end of the roll—in some instances, the overall mill layout, flow to the next mill, etc. may make it necessary to have the deepest pass in the cope end. When possible, however, this should be avoided since a deep pass in the cope end of the roll will restrict proper feeding of the lower portion of the roll.

Another factor—For maximum roll life, roll blueprints should call for the deepest passes at the driven end of the roll body. If you have a special reason why they must be located elsewhere, note it on the drawing; otherwise any roll maker worth his salt will ask you about it.

Another good rule to follow is to check with Mack-Hemp on any problem of roll selection or application. In a century and a quarter of making mill rolls, we have run across just about every conceivable situation involving the use of rolls. Our advice is yours for the asking. Feel free to telephone or write us at any time.

An important legend... for maximum roll life, the drag wabbler should be driven.

MACKINTOSH-HEMPHILL

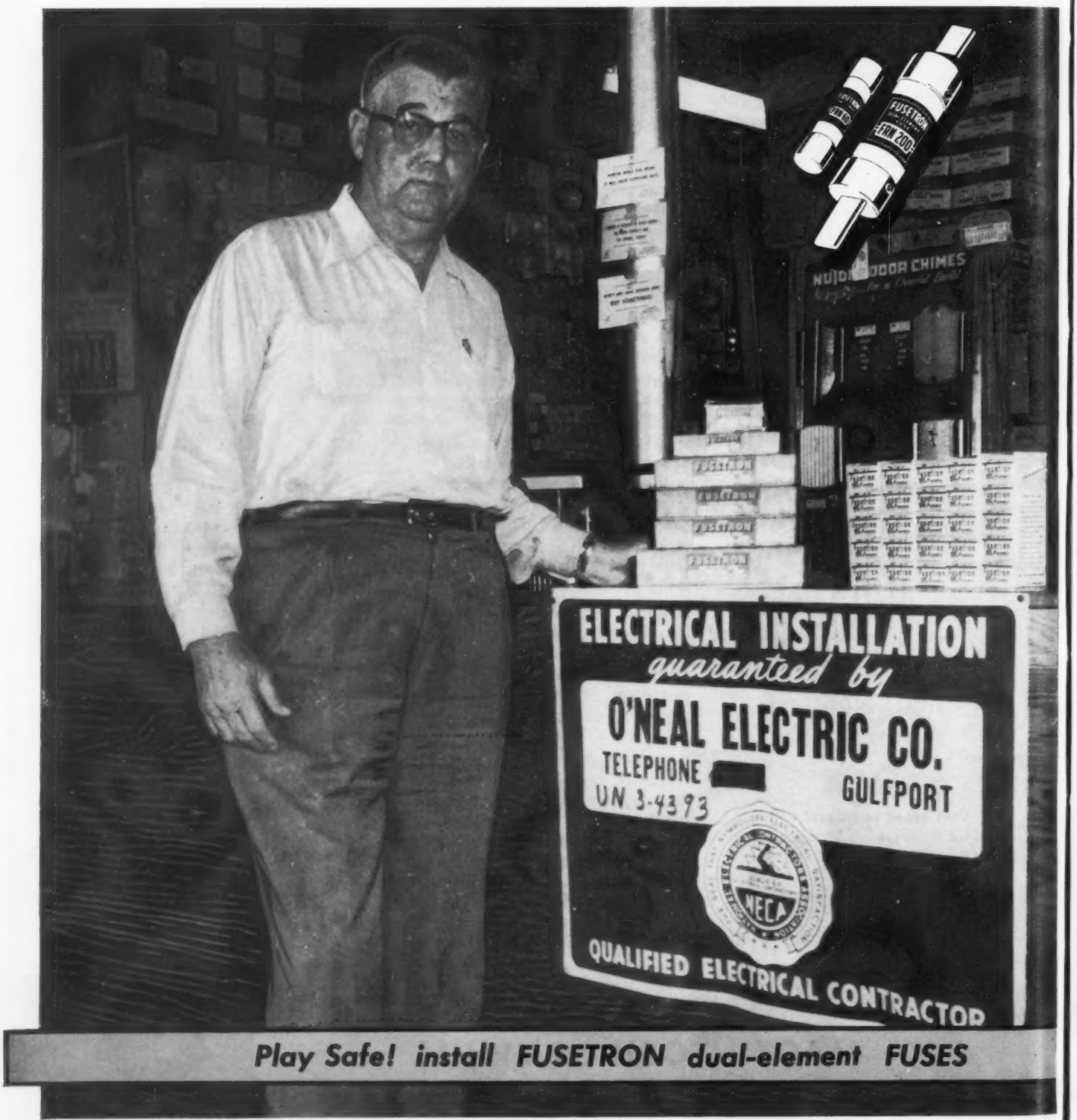
You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery

"We helped a customer stop frequent outages and get safe motor protection . . . by recommending FUSETRON Fuses"

OSCAR O'NEAL SR., PRES.
O'NEAL ELECTRIC CO., GULFPORT, MISS.



Play Safe! install FUSETRON dual-element FUSES

Mr. O'Neal continues . . .

"Sometime ago, the Gulfport Ice Co., called us in to do their electrical maintenance work. At the time, they were having a great deal of difficulty with motor starting currents causing ordinary fuses to blow. They were using 100, 200 and 400 amp. ordinary fuses to protect the motors.

"These frequent outages disrupted the company's normal operation and created a costly and annoying situation. Just to replace the 400 amp., 250 volt ordinary fuses was costing them about $40 a month.

"My first recommendation to them was to change to Fusetron dual-element fuses in the proper size for safe motor protection. They did.

"The installation of Fusetron fuses was the 'key' to the problem. In the past five years I do not recall one 400 amp. Fusetron fuse having blown — and outages on the 100 and 200 amp. circuits have been very infrequent."

YOU TOO, CAN GUARD AGAINST UNNECESSARY OUTAGES OR MOTOR BURNOUTS THAT CAUSE MEN AND MACHINERY TO STAND IDLE SIMPLY BY INSTALLING FUSETRON DUAL-ELEMENT FUSES THROUGHOUT THE ENTIRE ELECTRICAL SYSTEM.

In addition to saving you money by protecting against needless outages and motor burnouts

FUSETRON Fuses offer High Interrupting Capacity and Life-Time Dependability Essential to Modern Protection.

High Interrupting Capacity: With electrical network capacities steadily increasing, — a *modern* protective device must be capable of interrupting the heavy fault currents now available and to be adequately safe to allow for anticipated growth in service demands.

FUSETRON fuses give you this protection. They have an exceptionally high interrupting rating of 100,000 amperes rms symmetrical.

Life-Time Dependability: The increase in available fault currents has emphasized the need for dependability in modern protective devices, otherwise, serious fire and personal injury can result should the device fail to operate when an emergency arises.

FUSETRON fuses provide safe and accurate protection through the years as their operation depends on a simple thermal law. Unlike mechanically operated devices, Fusetron fuses have no hinges, pivots, latches or contacts to stick or get out of order.

Once properly installed, Fusetron fuses require no maintenance, — no periodic inspection and accompanying down-time.

If you are considering a new installation or the modernization of an electrical system — you can be sure of modern, safe, maintenance-free protection in 10 or 20 years by installing Fusetron dual-element fuses now.

For more information on FUSETRON dual-element fuses . . . Write for bulletin FIS.

BUSSMANN MFG. DIVISION
McGraw-Edison Co.
St. Louis 7, Mo.

380

throughout entire Electrical System!

FUSETRON — TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION — BUSS — McGRAW EDISON

Now Ohio offers FORGED SLEEVES for back-up rolls

Ohio Steel—specialists in manufacturing all types of iron, steel and forged steel rolls—now offers the rolling mill industry *a superior forged steel sleeve for back-up rolls.*

Ohio back-up roll body sleeves are forged and hardened from *balanced alloy vacuum poured degassed steel.* These sleeves are accurately machined and applied to either new or used forged steel or cast steel arbors.

Yes, Ohio Steel offers a complete back-up roll service. Ask your Ohio roll sales engineer about this modern facility that can help increase rolling mill efficiency.

- Carbon Steel Rolls
- Ohioloy Rolls
- Ohioloy "K" Rolls
- Flintuff Rolls
- Double-Pour Rolls
- Chilled Iron Rolls
- Denso Iron Rolls
- Nickel Grain Rolls
- Special Iron Rolls
- Nioloy Rolls
- Forged Steel Rolls

OR 41

THE OHIO STEEL FOUNDRY CO., LIMA, OHIO

PLANTS AT LIMA AND SPRINGFIELD, OHIO... *Virtually at the center of the steel industry*

Industry News...

SHEFFIELD TO ADD WIDE PLATE HEAT TREAT LINE

△ The Sheffield Division of Armco Steel Corp. has placed an order with Drever Co., for a continuous wide plate line.

About 500 ft in length, the line will consist of a 54-ft charge table, 135-ft hardening furnace, 6-ft conveyor table, 50-ft pressure quench, 50-ft side transfer car, 153-ft tempering furnace (reversible heating), another 50-ft side transfer car, and a 158-ft conveyor table (parallel to the tempering furnace).

In operation, the large conveyor table will be used to by-pass the tempering furnace or for repassing the plate through the tempering unit. A 24,000 gpm water supply system with a 250,000 gal reservoir provides water for the pressure quench. The furnaces are direct fired.

The line will be fully automatic, push button supervised from an air conditioned control room, with closed circuit television monitoring and phone intercommunication. Working under the direction of the control room operator will be a hook man at each end of the line, and an overhead crane operator.

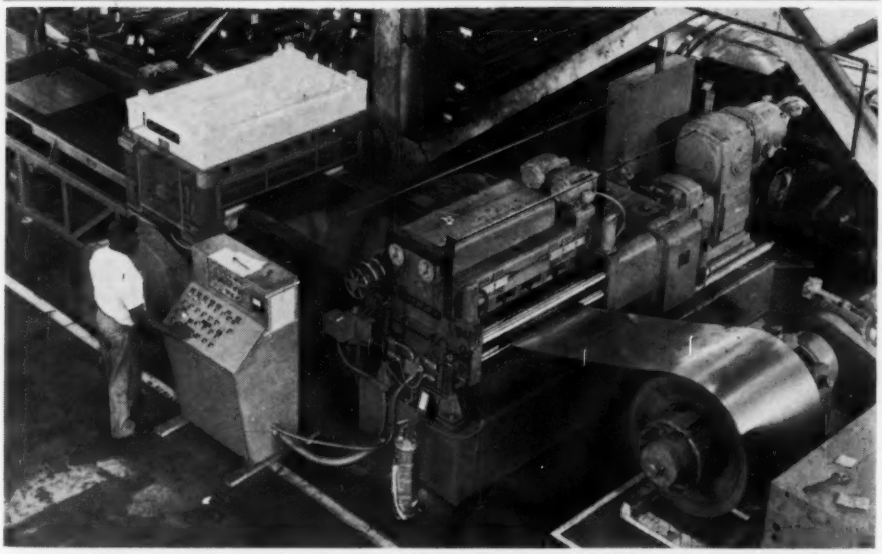
While designed to accommodate 160-in. plate, the line at startup will handle plate from Sheffield's 130-in. mill. The line is expected to be in full operation early next year.

BETHLEHEM IMPROVES ROLL MANUFACTURE

△ Bethlehem Steel Co. has announced that it will produce its entire line of hardened steel rolls from vacuum cast ingots.

The rolls, which until a few years ago were forged from air cast ingots, will be made available without any price increase over former air cast grades. Reason for Bethlehem's move is the superiority of rolls from vacuum cast ingots based on performances recorded over several years. In that period the company has produced and shipped several hundred large rolls to both ferrous

DIE SHEAR LINE AUTOMATICALLY PROCESSES COILS

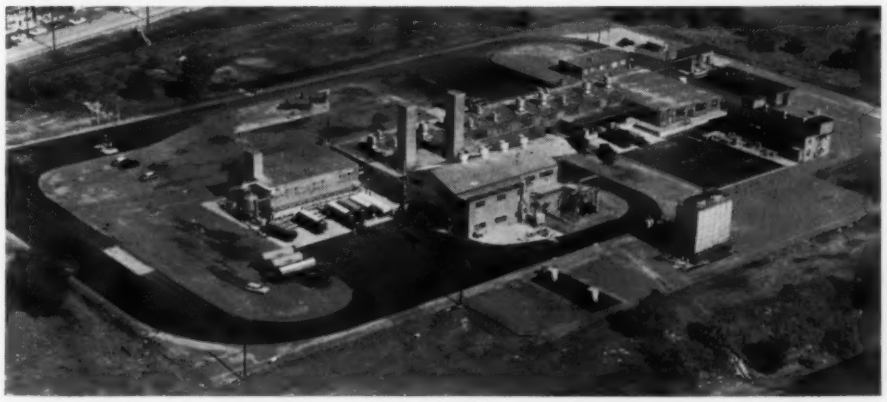


A new McKay die shear line, one of the first in the steel service center industry, has been installed at Caine Steel Co.'s Chicago plant. The unit will permit Caine customers to purchase coil steel in the most economical size, and have it cut to length and slit to width. In operation, coil steel mounted on a holder is fed into the die shear's first stations—the roller levelers. The strip steel after passing through the rollers is commercially flat and secondary rolling is not required. A traveling die holder then accelerates to the speed of the strip and cuts it to preset length and then returns to its original position. Pulses from a pulse generator on the exit pinch roll are relayed to a small electronic counter which controls the length of cut. The operator can change this length instantaneously by pushing buttons on a control panel.

OXYGEN FIRM DEDICATES NEW PLANT

Air Products, Inc., dedicated a new oxygen plant at Creighton, Pa., in the Pittsburgh district, capable of producing 200 tons per day of liquid oxygen and liquid nitrogen (about 144,000,000 cu ft per month) plus 4,500,000 cu ft per month of argon. The plant was built at a cost of about $6,000,000.

Along with the dedication, Air Products displayed their new oxygen-fuel lance which promises to markedly shorten steelmaking time in the open hearth. Units will release heat at rates up to 50,000,000 Btu per hour and larger ones are under consideration. Preliminary test results of the use of such lances indicate that heat requirements in the open hearth may be reduced to as low as 1,000,000 Btu per ton, and these fuel savings may be more than enough to pay for the cost of the oxygen and natural gas.



Get real value in lifting magnets from STEARNS

Red hot billet handled with ease by Stearns 65-in. circular lifting magnet capable of lifting up to 65,000-lb loads

Stearns value means highest performance and durability at the lowest cost

Stearns *value* is backed by 50 years of service to the steel industry.

Standard circular or rectangular magnets are available in either bolted or all-welded styles, in a wide range of capacities and sizes:

Circular — standard duty, 4 coil magnets — 20" to 77" dia.
deepfield, 6 coil magnets — 55" and 65" dia.

Rectangular — 9"x 24" to 26"x 80"

Whatever your steel-handling problem, Stearns engineers have the answer with built-in value.

Check these features:

- Deep-ribbed case for cooler, more efficient operation.
- Magnetic field design provides superior perimeter lifting power.
- Bronze "shock absorber" coil cover for additional protection against shock and jars.
- Waterproof construction.
- Permanently sealed magnet coil with vacuum-impregnated windings.
- Special laminated mica insulation provides extra protection against shorts, burn-outs and current leakage.
- Leads and terminals fully protected against abrasion and shock.

Call in your local Stearns representative for a job-studied recommendation and price quotation, or write for Bulletin No. 35CJ.

STEARNS MAGNETIC PRODUCTS

DIVISION OF INDIANA GENERAL CORPORATION • VALPARAISO, INDIANA

635 SOUTH 28TH STREET • MILWAUKEE 46, WISCONSIN

Profit with Stearns — Pioneer Builder of Lifting Magnets

and nonferrous industrial users.

Through its vacuum casting process, Bethlehem has reduced the volume of hydrogen and other gases in the ingot to a harmlessly low level. As a result, hardened steel rolls now can be forged from sounder, tougher and cleaner ingots with the possibility of flaking or micro cracking greatly reduced.

The intermediate size rolls (14 to 21-in. diam) and large size rolls (21 to 37-in. diam) are forged from 62- and 78-in. ingots.

In Bethlehem's vacuum pouring process, steel melted in the electric furnace is poured either into a pony ladle at the top of the vacuum pouring unit into an ingot mould, or from the furnace ladle into a second ladle contained in the vacuum tank.

Steel flows from the pony ladle or the furnace ladle through a high vacuum in the degassing chamber. The flow is actually spray in contrast to the tight rope-like stream of the air cast ingot. The disintegration of the hot metal into small droplets releases the hydrogen as well as other gases.

Tests taken from the furnace ladle compared with tests taken from the molten degassed metal indicate a hydrogen removal averaging approximately 63 per cent. A typical analysis of gas samples taken from the vacuum line indicates hydrogen 31 per cent, nitrogen 36 per cent, carbon monoxide 29 per cent and the remaining four per cent carbon dioxide and oxygen.

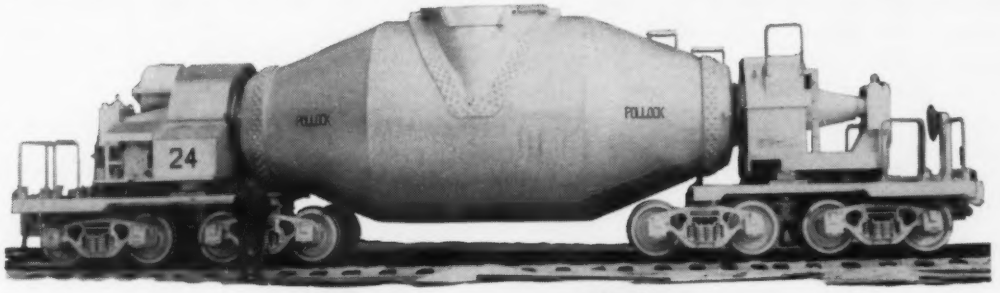
While the process and subsequent heat of forging may reduce hydrogen in the exterior portions of the air cast ingot, the interior content remains at high level. In vacuum cast steels, however, the low hydrogen content is found throughout the ingot cross section. Besides eliminating flaking or micro cracks, the removal of hydrogen in the vacuum pour greatly minimizes embrittlement tendencies in larger forgings.

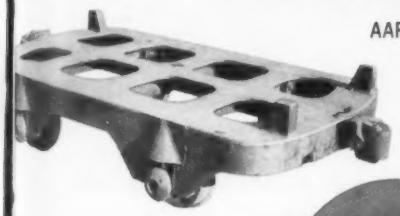
In ultrasonic testing throughout processing and before final machine finishing and polishing, sound waves pitched at high frequencies search out any sort of discontinuity within the rolls.

Hardness tests are made after hardening and drawing to customer requirements. Final surface finishing as required by the customers is obtained and the roll is then ready for final inspection.

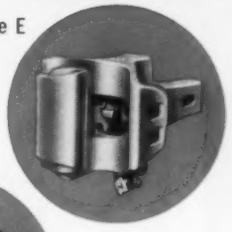
CAR PROTECTION !

There's a National combination of Coupler and High Capacity Rubber Draft Gear to fit your car and its protection needs. Increase car availability, reduce maintenance time and cost.

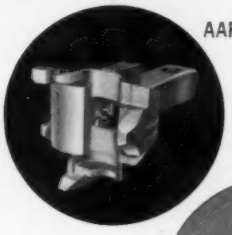




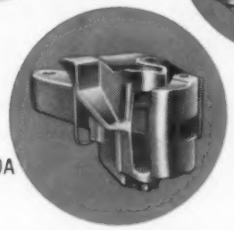
AAR Type E



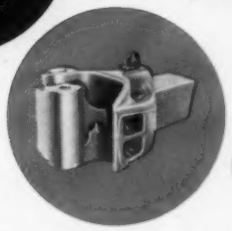
AAR Type F



Sharon-10A

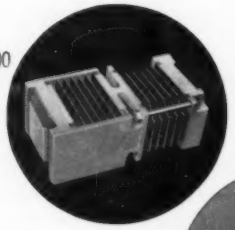


NATIONAL COUPLERS

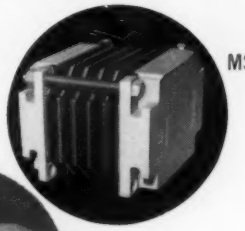


National AP

MF-400



NATIONAL RUBBER DRAFT GEARS



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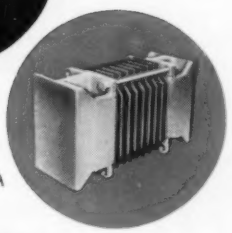
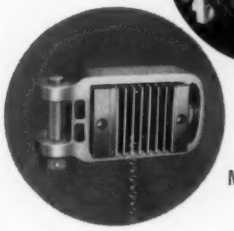
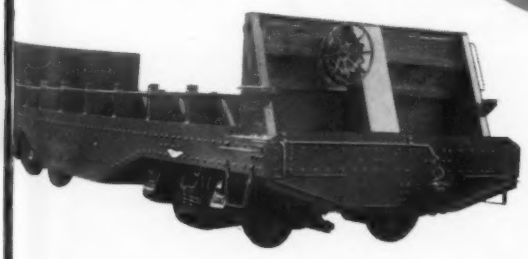
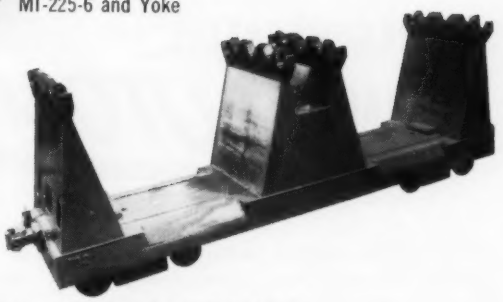


MF-491-A

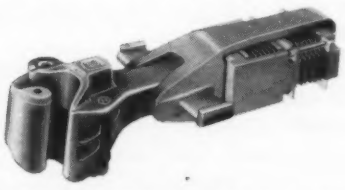


MI-225-6 and Yoke





Transportation Products Division



Type E coupler and MF-400 gear assembly

NATIONAL
MALLEABLE AND STEEL
CASTINGS COMPANY

Cleveland 6, Ohio

A-2361A

RESEARCH CENTER ADDS NEW COMBINATION PRESS

△ Republic Steel Corp.'s Research Center at Independence, Ohio, has installed a new type 500-ton oil-hydraulic combination forging and extrusion press that permits unusually high speed and flexible operation. The press, built by Birdsboro Corp., is being used to explore the behavior of new metals under both forging and extrusion conditions.

On forging cycle, the machine is capable of fifty one-inch strokes per minute for fast working before the material loses heat. Extrusion speeds, remotely controlled and varied through a direct control lever, range from 15 in. to 150 in. per min during the extrusion cycle.

An interlocked hydraulic-electric circuit gives the machine its unusual flexibility in operation. A selector switch makes it possible to change from one cycle to another.

The press is set up for manual forging, semi-automatic forging and manual planishing. It extrudes vertically and is capable of advancing on the work at a rate of up to 600-in. per min.

The extrusion stem on this press is attached to the moving platen. A shear is built into the extrusion tooling, at the bottom end of the stationary type container, to cut off the extruded piece. Tooling is so arranged that the butt and die can be pushed through an opening in the shear.

Anvils for the bottom platen are furnished with the press for forging. The press is driven by a 300 hp motor and two main radial piston pumps.

SIGNING OF AGREEMENT ANNOUNCED BY FIRMS

△ Strategic Materials Corp. has announced the signing of an agreement with Universal-Cyclops Steel Corp. for the joint development of the use of the Strategic-Udy processes in the production of materials for use in stainless steels and/or heat resisting alloys.

Under the agreement, Strategic Materials will build a $1,500,000 addition to its plant at Niagara Falls, Ontario, and it is expected to be in operation around the end of this year. This represents a large scale increase in the pilot plant facility that has been in operation for nearly three years exploring the use of low-grade ores previously considered unusable.

Frank W. Chambers, president of Strategic Materials Corp., explained that the Strategic-Udy processes for the first time may permit the economical utilization of low-grade lateritic and chromite ores in the commercial production of high quality stainless steels and/or heat resisting alloys. Such low-grade ores are available in abundance in many areas of the world and this development would provide markets for such deposits.

Strategic will build the new plant addition and be responsible for its operation while Universal-Cyclops will furnish technical assistance. The plant addition will include an electric furnace and a kiln as well as auxiliary facilities.

ANNOUNCES FORMATION OF CONSULTING FIRM

△ The Kerma Corp. was recently organized by Ross McCready, formerly director of engineering of Alliance Machine Co. The firm's primary purpose is to offer design and consulting services in the field

The BLOOM Time-Cycle Reversal Unit

assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY

This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It eliminates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.

BLOOM ENGINEERING CO., INC.
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WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

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This "custom-built" SECO 60" Slitting Line, recently installed in a midwestern steel company's plant, was designed and built to their exact specifications to provide maximum performance.

Features of this custom-built SECO Slitting Line are:

- Coil weight capacity—40,000 lbs
- 225 fpm line speed with build-up to 735 fpm
- .1875 max. material thickness—5 cuts
- .020 min. material thickness—20 to 30 cuts
- Line arranged to handle sheets or coils
- Power driven hold-down rolls for uncoiling heavy gauge material
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- Variable speed D.C. drive
- Control equipment at operator's desk
- Over-arm separator at recoiler
- Removable housing assembly for quick knife changeover away from slitter

Whatever your requirements, SECO can provide a complete range of Slitting Lines—from 12" to maximum strip widths—as well as other Steel Mill equipment. SECO's staff of trained sales engineers are at your service to assist you with any production problem you may have. Call or write today.

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- Leveling and Shearing Lines
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- Narrow Strip Grinding Machines
- Slitting Lines
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TM Alloy Chain is used wherever rugged "brute strength" is a requisite. For example, the working load limit of ¾" TM Alloy is 23,000 pounds. It's tougher, safer and far less costly than other grades of chain tested. Order to your specifications. Available everywhere from Industrial Distributors, Steel Warehouses and Hardware Wholesalers.
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Everything Swings on TM Slings

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of heavy and special materials handling equipment.

The company will be headquartered in Alliance, Ohio, at 1511 East State St.

TIMKEN INSTALLATION CUTS MAINTENANCE COST

△ A system of new manifolds and exhaust piping for the Timken Roller Bearing Co.'s vertical gas carburizing furnaces are now in use at the company's Columbus, Ohio, plant and will soon be used at its main plant in Canton. The new system consists of a heavily insulated manifold and a pilot line of reduced size. The new dimensions and heavy insulation maintain a high degree of temperature which burns up the carbon.

In the past, manifolds and exhaust piping on these furnaces did not hold the temperature and filled with carbon and required regular cleaning. They had to be removed so the carbon could be burned out. With the new installation, this regular cleaning is no longer necessary. Frequent installation of new pipe has also been eliminated. The reduced maintenance and longer life of the new manifolds have resulted in a considerable cost savings.

FIRM ANNOUNCES CHANGE OF CORPORATE NAME

△ The stockholders of the L. R. Kerns Co. have voted to change the corporate name to Kerns United Corp.

In view of the company's extensive expansion program, which includes increased national and international sales coverage, product diversification and additional manufacturing facilities, it was felt that the new name would be more descriptive of the entire operation.

Several years ago, a new plant and office facility was erected at Orange, Calif., and current plans now call for manufacturing and laboratory facilities in the East coast area as well as in Canada.

ADDS NEW FACILITIES TO SHIP TINPLATE COILS

△ A program which will increase facilities for the shipment of tinplate in coils at the Aliquippa

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. . . . . for air separation plants designed for steel mill applications, think *first* of American Messer.

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MYTHOLOGY: The Midas Touch changed objects into gold.

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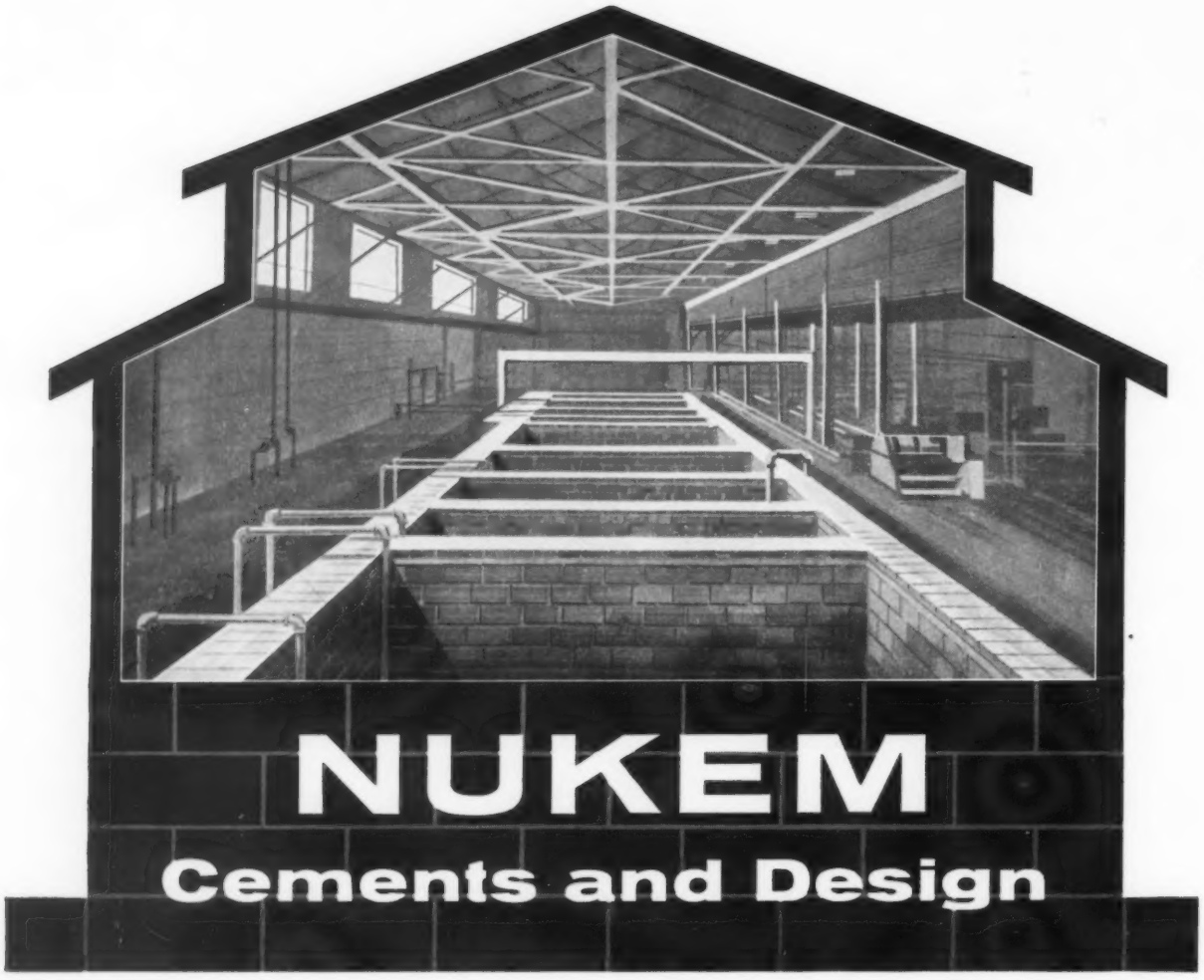

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Sulphuric, hydrochloric, nitric or hydrofluoric acids... nickel salts or caustics... no matter what corrosive solutions your processes require, there is a Nukem cement designed for your service.

For over 35 years, Nukem has specialized in the manufacture of a complete line of acid and/or alkali proof cements and linings—each bearing the hallmark of "top quality." Over this same period—employing these products—the name NUKEM has been associated with successful, reliable, corrosion proof construction of Pickling Tanks, Neutralizing Systems, Foundations, Manholes, Trenches and Sewers.

Permanent, satisfactory results depend upon accurate analysis of the problem and selection of the exact material to meet every requirement. Proper design is essential and Nukem engineering "know-how" is at your service. For lasting and economical corrosion resistance, be sure you specify NUKEM.

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For information and illustrated technical data write:

NUKEM PRODUCTS CORP.

Dept. 5H • 111 Colgate • Buffalo, N.Y.

A Subsidiary of Amercoat Corp.

N 102

Works of Jones & Laughlin Steel Corp. has been announced.

The new facilities will include a coil packaging line, new heavy duty tractors, truck loading equipment and extensions and changes to existing truck and railroad loading docks.

Installation has been started, and this phase of the program should go into operation late this year. Additional equipment will be installed at a later date.

Tinplate coils are shipped in a position different from that usually used for coils. The large coils are placed on pallets with the core or "eye" vertical, as compared with the previous method of shipping smaller coils in an upright position on platforms with the "eye" horizontal.

The eye-vertical position enables two or three coils to be placed on top of each other in storage. This results in a savings of storage space—an important consideration in the can manufacturing industry which must build up large inventories during peak production periods.

CONTRACTS AWARDED TO PITTSBURGH ENGRG.

Δ Pittsburgh Engineering and Machine Division of Textron, Inc., is building slab shearing, conveying and piling equipment for a blooming mill at the Brier Hill Works of the Youngstown Sheet and Tube Co. The firm is also building slab handling facilities for the number 2 blooming mill at the Campbell Works.

The equipment for Brier Hill includes a mechanical up and down cut shear to cut mild steel slabs and blooms at approximately 1800 F. It is designed to take slabs up to 55 in. wide and 8 in. thick and blooms up to 17 in. wide and 13 in. thick.

The order for the Campbell Works includes slab pushers, screw type slab pilers, roller tables and slab transfer units. Slabs weighing up to 40,000 lb, measuring 24 to 74 in. in width and 10 to 26 ft long will be handled on the new facilities.

CONTRACTS AWARDED TO A. G. McKEE & CO.

Δ Arthur G. McKee & Co. has been awarded contracts for the engineering and construction of two major new iron ore agglomerating facilities.

The firm will build the pelletizing unit for the 900,000 ton per year expansion project at the Republic Mine in Republic, Mich., announced recently by the Cleveland-Cliffs Iron Co., and also the agglomeration section at the new iron ore mining and processing installation of United States Steel Corp.'s Columbia-Geneva Division near Atlantic City, Wyo.

McKee will handle the engineering, purchasing and construction of the agglomeration plant for the Atlantic City project with the exception of steel fabrication and erection, which will be done by U. S. Steel's American Bridge Division.

The plant will be capable of turning out more than 4000 tons of high grade iron ore a day and will utilize a process developed jointly by McKee and Allis-Chalmers Mfg. Co.

The facilities at the Repbulic

(*Please turn to page 214*)

IT'S OUR FAULT!

We thought everyone knew the advantages of using the Atlas Dial Scale with enclosed mercury switches to automatically control coke weighing at the skip hoist.

The important and outstanding advantage is that the tripping point can be set instantly by anyone from a knob outside the dial. No skilled technician is necessary.

Contacts, zero and adjustable trip, can be either make or break, as desired.

Enclosed dust and waterproof mercury switches to control weighing.

Outside knob adjustment on dial face to set tripping point.

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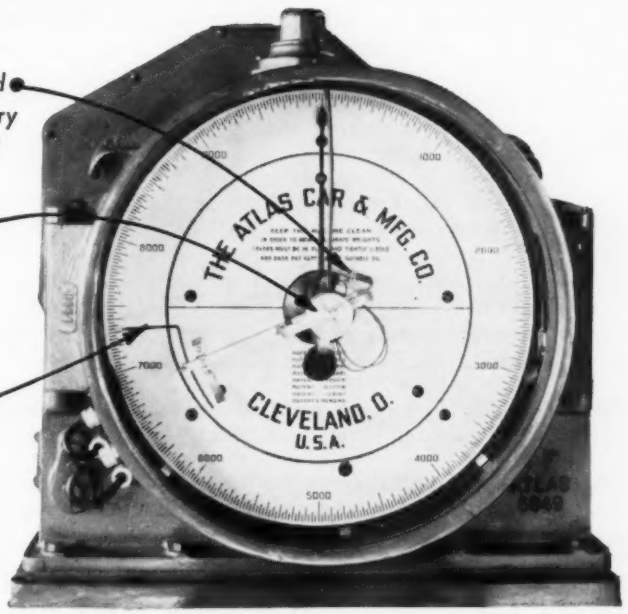

Ask for Bulletin 1290 for details.

Also for use with Electronic Scales.

ATLAS CAR & MFG. CO.

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PROGRESS REPORT

STORA-KALDO OXYGEN STEELMAKING DEVELOPMENTS

In England, the Consett Iron Company Limited recently announced plans to install two 110-ton Stora-Kaldo convertors . . . in France, Sollac (Societe Lorraine de Laminage Continu) began operating their new 110-ton Stora-Kaldo converter in April . . . in Oxelosund, Sweden, another facility with 110-ton vessels will start production early in 1961 . . . in Domnarvet, Sweden, installation of converters of comparable capacity has been programmed.

The original 30-ton facility at Domnarvet has passed the three-hundred-thousand-ton mark. Steelmakers from the United States have witnessed production, by this process, of a wide range of grades of carbon steel—1005 to 1095—without recarburization. The specified steel chemistry and tapping temperatures were met exactly. Slabs and ingots were shipped to the United States and processed into finished products, ranging from deep-drawing material to cutlery stock. Comments from ultimate users ran from "good" to "the best material we ever had."

These events and the facts detailed below are causing more and more steel producers to take a close, hard look at the Stora-Kaldo process:

FACT NO. 1. What is believed to be the largest single heat—122 tons—ever produced in a basic oxygen converter of any type was produced by Sollac with its Stora-Kaldo facility (23 cubic feet of furnace volume per ton of rated capacity). Consistent heats of 130 tons and more are programmed as this installation reaches normal production later this year.

FACT NO. 2 The ingot yield of virtually every heat at Sollac *has exceeded* 90 per cent since operations started.

FACT NO. 3. Capital costs for a Stora-Kaldo installation are comparable to or lower than competitive processes for equivalent capacity and conditions.

FACT NO. 4. The Stora-Kaldo process is inherently flexible in its ability to produce, within precise metallurgical limits, a wide variety of carbon steels on a heat-to-heat basis—not a "hit or miss" basis—without recarburization and at desired tapping temperatures.

FACT NO. 5. Slag analyses show refractory consumption of 24 pounds per ton of steel, during initial operations of a 110-ton Stora-Kaldo converter, when heat times were considerably longer than normal during crew training programs. This performance substantiates the value of recent lining design developments and assures continuous operation of two vessels in a three vessel plant.

FACT NO. 6. The process can be operated with 96 to 98 per cent purity oxygen to produce steel having a nitrogen content of .003 per cent or less. A typical heat analysis using 99.5 per cent oxygen showed:

	Hot Metal	*Ladle*
C	3.6	.061
Mn	.330	.395
P	1.7	.015
S	.045	.011
N_2	—	.002

FACT NO. 7. Oxygen flow rates currently are 5,000 cubic feet per minute and are being accelerated. Oxygen consumption is approximately 1,950 cubic feet per ton of steel when scrap is used for cooling.

FACT NO. 8. High percentages of scrap and ore can be used for coolant. The thermal efficiency of the process permits scrap addition of up to 50 per cent of total metallics charged. This will produce one and three-quarter tons of steel per ton of hot metal. If ore is used for coolant, approximately one ton of steel is produced per ton of hot metal.

FACT NO. 9. Size of gas cleaning equipment required is modest because carbon monoxide is almost totally burned inside the furnace. The exhaust hood is a simple water-cooled duct. The oxygen lance is a water-cooled pipe which projects through and is connected to the hood. The lance is automatically positioned as the hood is moved into place. Normal lance life is in excess of one thousand heats.

Engineering specialists are available to prepare economic and feasibility studies to help you evaluate the Stora-Kaldo process as it applies to your individual operations. Under United States and Canadian rights granted by Stora Kopparbergs Bergslags Aktiebolag, Sweden, Dravo can furnish complete design, manufacturing, construction and installation of Stora-Kaldo facilities, providing undivided responsibility for the entire contract.

For more information, write or phone Dravo Corporation, Pittsburgh 22, Pennsylvania, EXpress 1-2600.

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CORPORATION

—SHARP FOCUS ON BETTER STEEL PRODUCTION

when things are HOT... call on Duraloy

A design of the A. F. Holden Co., Detroit, Mich.

Castings that Keep their Load-Carrying Strength at High Temperatures

This "immersion type radiant heater" is typical of the high reliability castings turned out by DURALOY. Centrifugally cast tubes with *UNIFORM* wall thickness...for longest service life. Static cast collars and shell molded bends...typical of DURALOY versatility.

For your high alloy casting requirements check with DURALOY... our long experience, ultra-modern foundry and up-to-the-minute test equipment will be helpful in solving your problems. For more information ask for Bulletin No. 3150 G.

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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Ave., Pleasant Ridge, Mich.

(*Continued from page 211*)

Mine and the concentrating and pelletizing plants are properties of the Marquette Iron Mining Co., operated by Cleveland-Cliffs and owned by Cliffs, Jones & Laughlin Steel Corp., International Harvester Co., and Wheeling Steel Corp. Capacity of the Republic plant will be boosted from the present 700,000 tons of iron ore concentrate to 1,600,000 tons per year. Half of this product will be processed into pellets through the new facilities at the Republic plant.

This expansion closely follows that of Humboldt Mine for which McKee also built the pelletizing unit. The Humboldt Mine facility which is about to go into production will be the first commercial application of the grate-kiln pelletizing process developed by Allis Chalmers. The new pelletizing unit at the Republic Mine will also use this process.

TO BUILD NEW BLAST FURNACE AT DUQUESNE

△ United States Steel Corp. has announced it will build an ultra-modern blast furnace at Duquesne Works. This furnace will ultimately replace certain older, smaller furnaces in the area.

Designed to help the corporation meet its long-range needs for molten iron to supply steelmaking furnaces in the Monongahela Valley, the new blast furnace will also incorporate advanced features that will enable it to be used in the pursuit of research studies into blast furnace operating problems.

The 28-ft-hearth blast furnace will be designed to allow for research studies on the effects of high top pressures approaching 30 lb; high hot-blast temperatures in the range of 2000 F; controlled sizing of the burden; automatic probing of the stock column; and advanced instrumentation.

Scheduled to be completed in two years, the new furnace is expected to produce about 850,000 tons of molten iron annually.

Meeting

△ The Galavanizers Committee of the steel industry, which is sponsored by the American Zinc Institute, will hold its 42nd meeting, October 27–28, 1960, at the Onesto Hotel, Canton, Ohio.

Vol. 7 No. 2

NATIONAL CARBON COMPANY'S

CARBON AND GRAPHITE NEWS

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LUKENS STEEL COMPANY'S ELECTRIC FURNACE

a year of operation proves our decision was wise!

L. P. McALLISTER

LUKENS STEEL C
ELECTRIC F

a year of operation proves ou

L. P. McALLISTER
General Manager, Production
Lukens Steel Company

After a year of operation, the 100 ton electric furnace has proved to be an efficient, economical, and flexible tool for our steelmaking program. The installation was made after years of investigation into the type of equipment which would best serve our needs. After working with this equipment, we have found that the electric furnace is all we predicted it would be and in many instances its performance far surpasses our predictions. The major advantages we have realized with the electric furnace are:

- *LOWER FIRST COSTS*
- *LOWER PRODUCTION COSTS*
- *INCREASED OUTPUT*
- *FASTER HEATS*
- *FLEXIBILITY OF PRODUCT PRODUCED*
- *FLEXIBILITY OF OPERATIONS*
- *LOWER MAINTENANCE COSTS*

Introduction

For many years, Lukens Steel Company has invested large sums of money in expansion and improvement programs in order to meet the challenge of a highly competitive industry that constantly changes because of technological developments. The advances have brought Lukens step by step from a company that was built on the banks of the Brandywine 150 years ago by Isaac Pennock, to a company that today is an inspiring example of the best American tradition in the production of iron and steel.

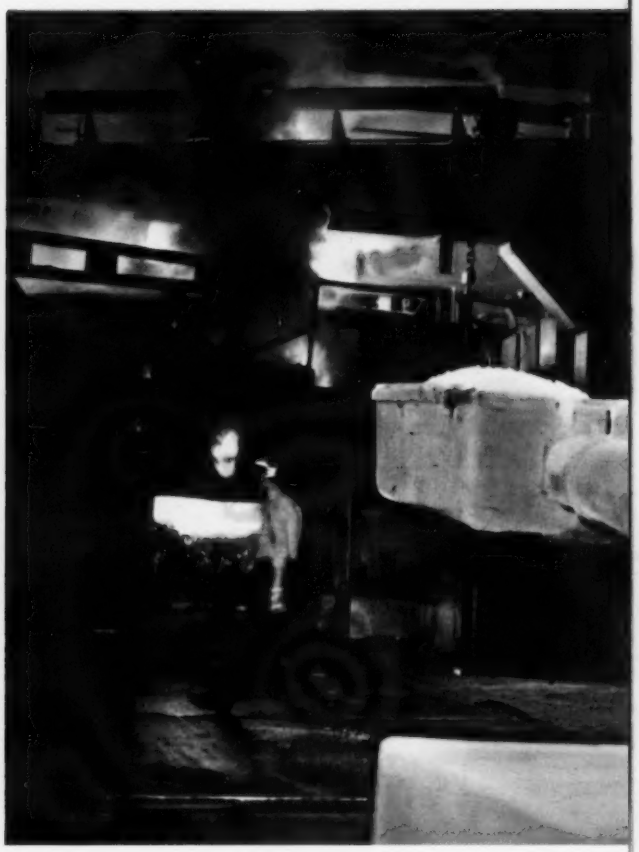
Some of the changes we have made since our early days were minor and some were major in nature. As recently as July 1957, ground was broken for the largest single expansion program in our company's history. When the program was completed in April 1959, we had invested roughly 33 million dollars in steelmaking, heating, and rolling equipment. Approximately 12 million dollars of th total applied to a 100 ton top-charge electric furnace plu accessory equipment and building. The remaining 2 million dollars covered installation of a four-high 14 inch slabbing mill and added heating capacity and ex panded finishing area.

This expansion program raised our ingot-making capac ity by 24 per cent from 750,000 ingot tons a year to 930,00 ingot tons; the new slabbing mill increased rolling capac ity of the combined mills by approximately 40 per cen

Any company planning a major expansion progra such as this would naturally be as thorough as possibl in investigating approaches that add up to a sound, eff cient and economical solution. Actually, our needs coul

L COMPANY'S C FURNACE...

ves our decision was wise!



best be answered by adding one of two types of steel-making equipment, the open hearth or the electric furnace.

Having been associated with open hearths for a long period, we knew from experience primarily what to expect from this equipment and also knew its limitations. We were not familiar with electric furnace operations at all. This subject required very close investigation before a decision could be reached. And, only after years of intensive scrutiny did we decide that the electric furnace best suited our needs from both an economical and production standpoint.

In this article, I shall relate some of the reasons why we chose the electric furnace . . . our basic thinking and predictions prior to installation . . . and finally, the results we have realized after a full year of electric furnace operations.

ADVERTISEMENT

Electric Furnace or Open Hearth Capacity

We at Lukens spent several years investigating the type of ingot-making equipment which we would eventually install to meet the increasing demands of our expanded markets. A committee, comprised of personnel from our operating, metallurgical, engineering, and accounting departments, approached the task of investigating this subject thoroughly.

As was mentioned previously, we have had many years of experience with the open hearth furnace. We knew that added capacity utilizing this equipment would naturally involve purchasing additional high-priced iron on the open market. With this in mind, we considered the possibility of installing a cupola in our plant to produce our own hot metal.

At approximately the same time, we started to examine the electric furnace closely. Some of our committee visited plants utilizing electric furnaces to gain first-hand knowledge of their operations, practices and experiences. They talked with furnace manufacturers, with accessory equipment manufacturers, with electrode producers, and others, in an attempt to collect as much data as possible to help make a sound comparison between the electric and the open hearth furnace.

A Survey was Conducted

An intensive survey was conducted covering the major factors that would help guide us in our decision. In all cases, actual figures were gathered and plotted covering these subjects for the length of time required to establish a trend. In some instances this covered a period of fifteen years. The data were then projected to apply to the future.

Some interesting factors were derived from this survey material. One is the estimate that in the future there will be a favorable spread between the cost of iron and scrap in the industry. Also, the electric furnace in relation to the open hearth, offers a higher scrap to iron ratio, offers higher yields and provides improved costs for metallics.

Based on our studies and surveys, a report was submitted to top management recommending the installation of an electric furnace. The recommendation included th following predictions based on the installation of a 2 diameter shell, 100 ton top-charge electric.

- Investment in an electric furnace and build in would be considerably less than equivalent o pe hearth capacity.
- Costs per ingot ton of electric furnace steel shoul be favorable.
- Heats could be made faster.
- The electric would offer flexibility of product an operating schedules.
- Maintenance costs would be reduced.

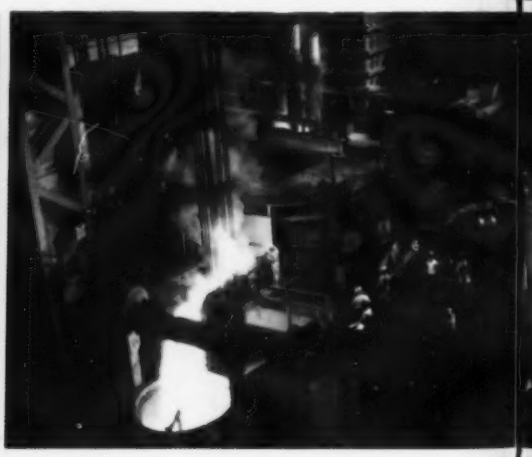
Results After a Year

After a little more than a year of operation, we find th electric furnace has done all we predicted it would d and in some instances it has surpassed our expectations The results show our original decision was wise. Th major advantages we have realized with the electric ar numerous. They will be covered not necessarily in orde of importance, but as they come to mind.

Costs

Our entire investment in the electric melt shop was roughl 40% less than it would have cost to install the equivalen open hearth capacity.

After the break-in period, during which time we had very few de-bugging operations, we find we have bee able to achieve and even better our cost goals compare to existing open hearth practices.



Production

A most dramatic feature, of course, is the production w have realized with the electric furnace. With our 10 ton unit we are producing the rated 20 tons per hour. Thi has been achieved with only a year's experience on ne equipment. Our average output with 135 ton cold charg open hearths runs about 9½ tons per hour tap to tap. No only is output of our electric running at more than twic

ADVERTISEMENT

hat of the open hearth, but in addition, the man hours equired per ton of steel produced in the electric run oughly 60% less than required with the open hearth. Over the next few years, as we gain added experience with the electric, we naturally expect to raise our tonnages er hour output.

Flexibility

Another feature of the electric furnace is the flexibility nd versatility it offers for our operations. We can produce lectric steel according to demand by running the arc urnace any number of shifts and any number of days er week. Presently, we are producing approximately 0% carbon and 30% alloy steels. We have also gained lexibility in our choice of charge materials. We average 3% iron charged in electric melting operations, although we are making some heats without any iron at all. Compare this with our open hearth practices where at least 30% high-cost iron must be charged in every heat.

Also, the electric permits us to consume larger quantities of home produced alloy scrap. This means we can recover valuable nickel and molybdenum that would otherwise have to be purchased on the open market.

Fast Heats

We feel that the melting speed of the electric furnace is another dramatic feature. On carbon heats, the average heat cycle in our electric is 4 hours and 30 minutes charge to tap. It is 5 hours and 20 minutes tap to tap. The latter figure allows for any minor maintenance between heats. Initially our heat weights in the electric were running 100 tons per heat. In the short period of one year we have raised this figure to 108 tons per heat.

Maintenance

We can completely reline our electric in approximately 16 hours. Naturally, this reduction in down-time for maintenance and repairs has reduced overall operating costs. In addition, it is our experience that the electric maintains a high level of output throughout the life of the lining, whereas our open hearths begin to drop off in production toward the end of each furnace lining campaign.

Some details of our electric shop experience may be of interest. We made the change-over with basically our open hearth crews, except for two electric furnace melters hired from outside the company. Our open hearth men trained for four weeks at a steel plant experienced in electric steel operations, and then joined our two electric melters to train first and second helpers. Presently, all the personnel working in the electric melt shop are from our open hearth department. These men became skilled in electric melting practices rapidly considering the differences encountered in melting practice.

Looking to the Future

As I remarked previously, we at Lukens feel we made a wise decision when we installed our electric furnace. And, the record of this ingot-making tool backs up our decision. Considering the scope of the change-over, authorities in the industry tell us our transition period was remarkably smooth with a minimum of major problems. A share of the credit goes to the Lukens' personnel who worked so diligently to achieve this installation and to those who contributed to the successful operation of the electric furnace. Also, we would like to thank and praise our elec-

ADVERTISEMENT

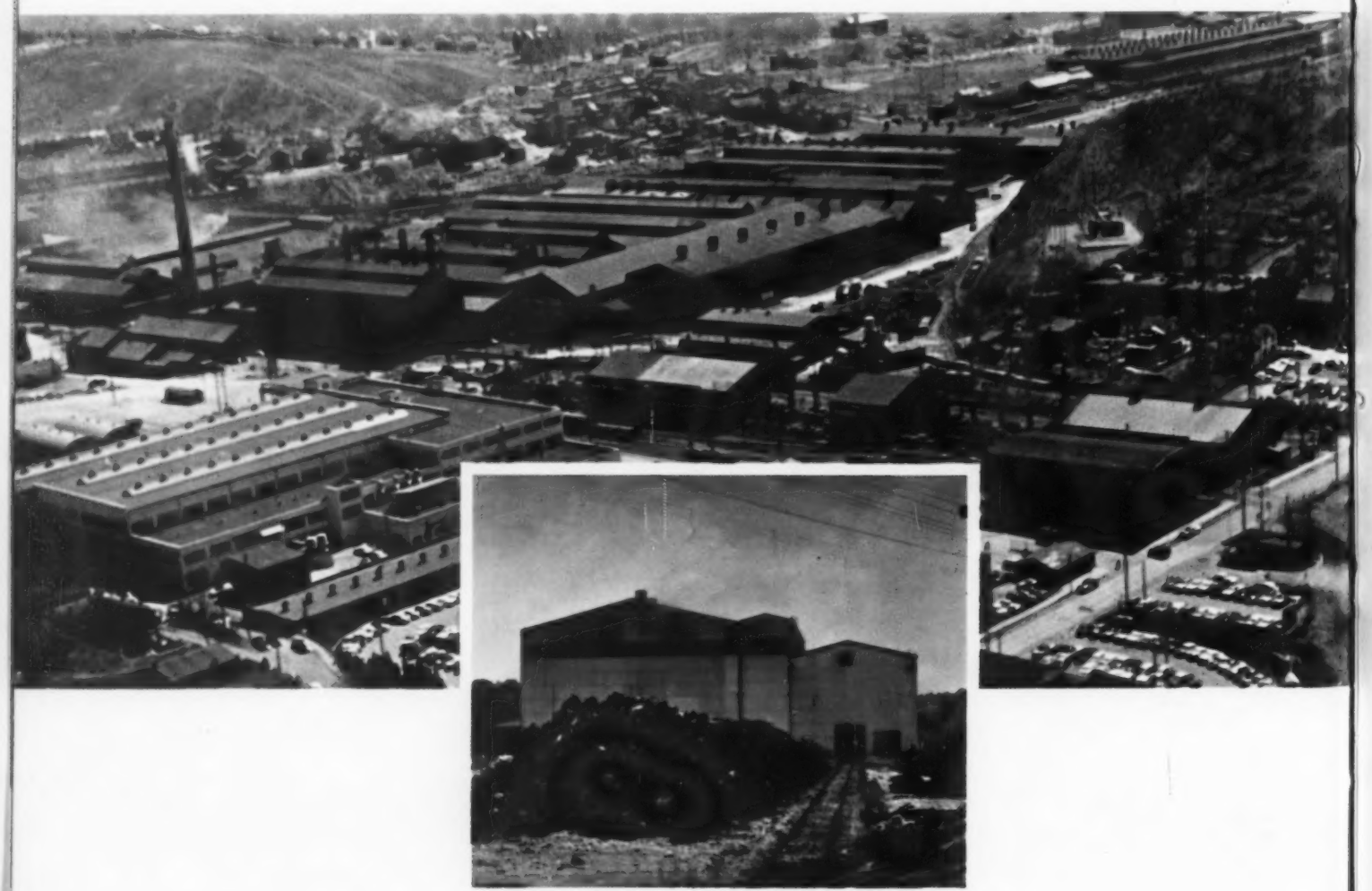
tric furnace suppliers who started us off in the right direction and, therefore, helped us avoid some of the pitfalls associated with a transition of this type.

Based on our experience, we feel that today's electric furnace is a highly efficient and economical production tool. We are also watching with interest the many technological advances – in a wide range of research, development, and pilot plant stages – that are bound to open vast new horizons for electric furnace steel operators. Some of these that come to mind are: the interest and activity in direct ore reduction processes, the use of oxygen in electrics, and today's practice of utilizing hot metal in the electric furnace.

Certainly, the electric furnace answers our needs of today, but it also answers the desire of Lukens' management to foresee future demands and developments and to take steps accordingly. We look forward to the time when demand will require the installation of additional electric furnace capacity. Our shop is now designed to accommodate two electrics and additional units can be installed with minimum alterations.

Planning such as this is one of the reasons why Lukens has maintained a reputation as a leader in the industry for a century and a half. From the rolling of boiler plates for 19th century river boats and locomotive engines to the production of integral parts for such wonders of the 20th century atomic age as rockets, missiles and nuclear submarines and merchant ships, Lukens has truly kept pace with the advances of man.

Our electric furnace will aid us in meeting the challenges ahead for continued growth, will help us keep pace with the stimulating competition of the industry, and will add to our ability to continue to produce "steels in step with science."



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NATIONAL CARBON COMPANY

Division of Union Carbide Corporation
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UNION CARBIDE

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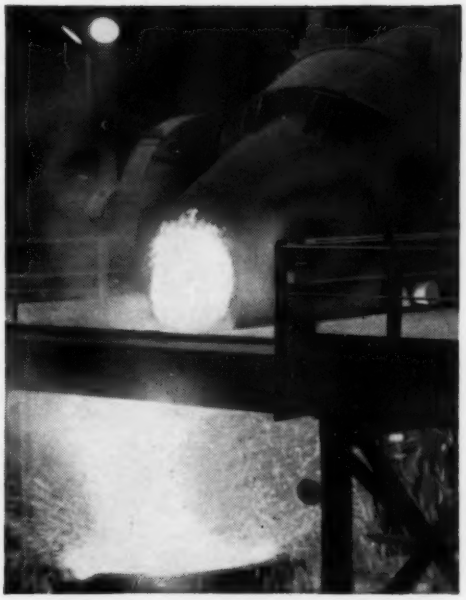
THE NOURISHING GAS



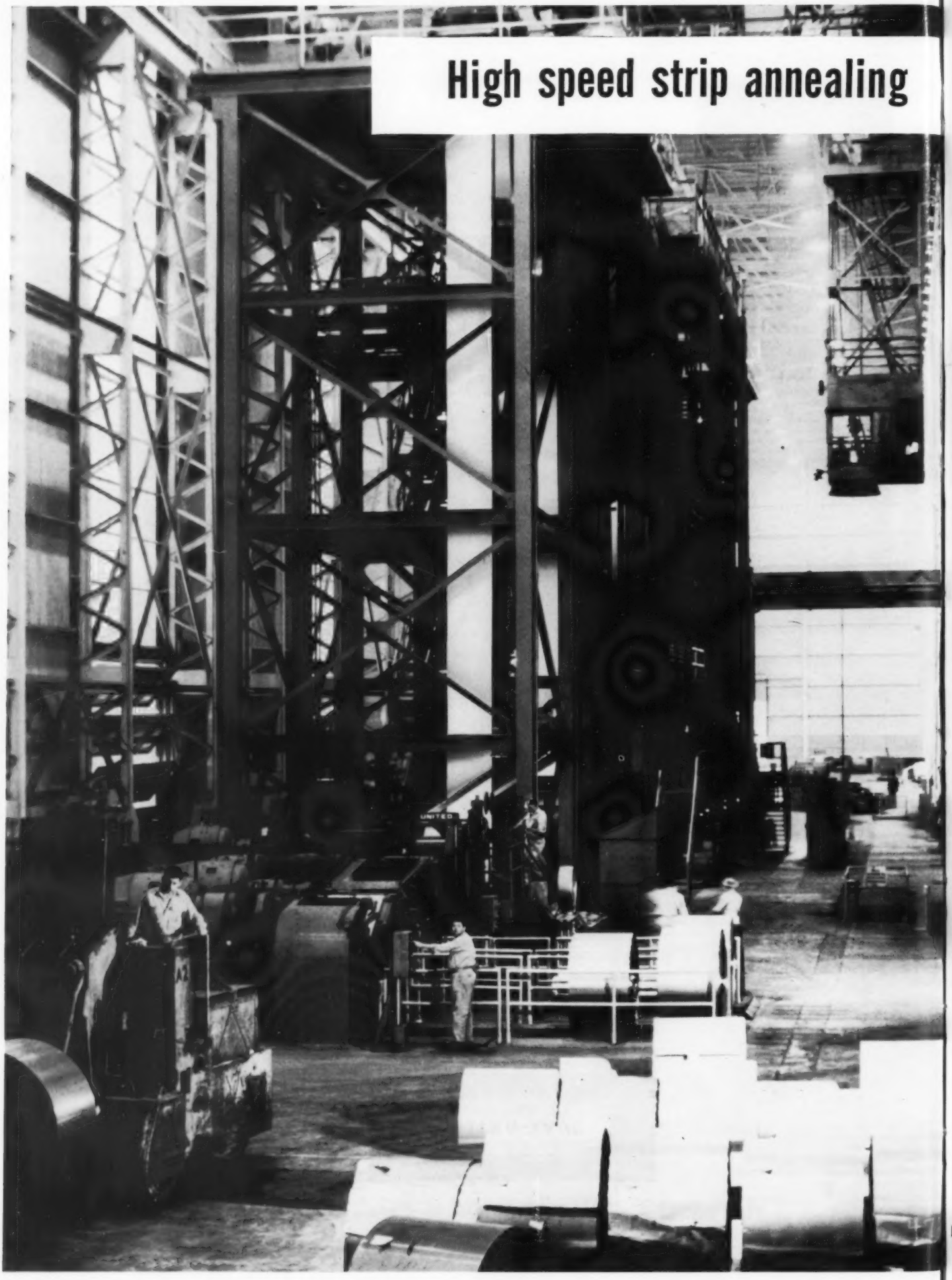
TO THE CHINESE
OXYGEN IS THE NOURISHING GAS.

To steelmakers in Britain and elsewhere, benefiting from the introduction of new oxygen steelmaking processes, the name couldn't be more apt. Oxygen is being increasingly used in the iron and steel industry. A converter furnace, employing oxygen for the blast instead of air, not only makes steel quicker than any other furnace, it produces steel of improved quality as well. Use of oxygen also enables the design of converter furnaces of much greater capacity, which means an installation of lower cost for any given output tonnage. Similar benefits accrue with any other steelmaking furnace. Faster production, better quality, reduced capital costs—strong nourishment in any language.
The design, engineering and supply of oxygen steelmaking plant up to complete melting shops is the main concern of Davy United's Steel Processes Division. In support of these services, the Division offers metallurgical, technical and economic surveys to help any company planning a new steelmaking development.

DAVY-UNITED STEEL PROCESSES DIVISION

SHEFFIELD, ENGLAND

High speed strip annealing



gives steel makers major cost and product benefits

Evolution of process gets major assist from Reliance's creative engineering

Speeds up to 2,000 feet per minute, thinner gauge steel, greater annealing uniformity, and higher tonnage output are the chief reasons for the spread of this process. Actually, lines like this one at Kaiser Steel can handle gauges from .0150″ down to .0070″ in coils up to 90″ outside diameter and widths of 42″ or greater . . . reducing costs in a growing tinplate industry.

Associated electrical equipment must be upgraded to meet the call for higher yield annealing lines. Reliance engineering is presently meeting that challenge. Here are some of the ways:

Furnace tension control

On advanced Reliance systems, the exit bridle is the lead and overall furnace tension is maintained by the entry bridle. Maximum line flexibility is provided, since the entry bridle can be position-controlled or tension-controlled. In tension-control, a regulator monitors the bridle torque, maintaining it at the pre-set level.

For position-control, a torque-regulated furnace tension unit position-controls the entry bridle. The tension unit consists of a short loop provided by a loaded roll, the position of which modifies the speed of the entry bridle. The roll may be locked in position when the bridle is directly controlling strip tension.

Helper drive torque regulation

Since it is economically unfeasible to regulate each of many furnace helper motors, the helpers have been grouped by furnace function (heat section, hold section, slow cool and fast cool). Each group is torque-regulated and each motor held within a group can be adjusted manually to take its share of the load while the entire section automatically holds its relative load position with respect to other sections. Reliance has encouraged the use of this system.

Reliance also strongly recommends the equipment explained below:

Strip-tension measuring load cells

These measure the strip tension existing at the exit end of each furnace section. Associated recording meters enable the operators to relate strip quality and elongation to helper drive torque settings of each section for different conditions of speed, gauge, etc.; in other words, able to study various settings of torque—and be able to repeat those which give the best results.

Automatic furnace tension control

The load cells provide an output signal which *can* be used as an input to the section torque regulators to maintain continuously desired tension. Correct inertia compensation for line speed changes is inherently provided by this system.

Synchro-control of looping tower

This eliminates inaccessible or hard-to-service photo-electric elements. A synchro is used to indicate and regulate tower position.

Automated strip feed-up

This increases the efficiency of entry end material handling, allowing high furnace speeds to be maintained.

It will pay you to discuss with Reliance engineers some of the fine points of annealing line system controls and drives. Creative application engineering, plus the ability to assume total responsibility through start-up and service are the reasons why Reliance is so readily acceptable at engineering, production and management levels of industry. Call your Reliance Sales Engineer. He has an office near you. If you prefer, write for Bulletin L-2513.

L-1672-BW

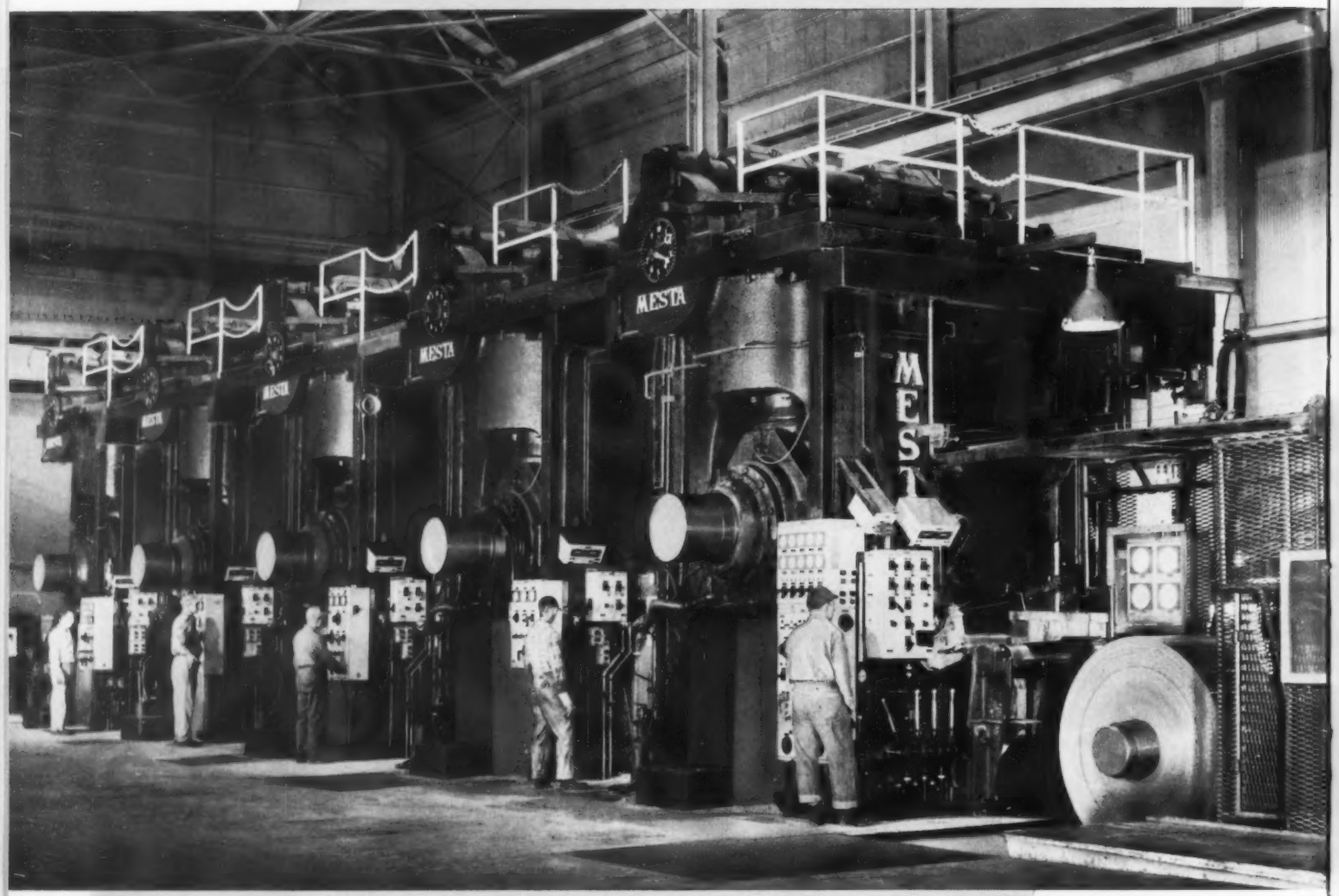
Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

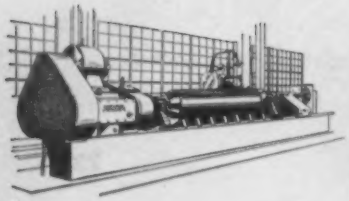
DEPT. 118A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

MESTA Cold Mills



MESTA 48" Four-High, Five-Stand Tandem Cold Mill
Rolling Strip Steel for Tin Plate in Coils



Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

Irving Whitehouse was appointed to director of research for Republic Steel Corp. He was formerly assistant director of research, and succeeds the late **Earle C. Smith. John Hazel,** former chief ceramic engineer and head of the ceramic division of the company's Research Center in Independence, Ohio, replaces Mr. Whitehouse as assistant director of research. Mr. Whitehouse joined Republic in 1935 as a sales engineer for the Steel and Tubes Division. He was made manager of the company's Process and Product Development Division in 1940 and became assistant director of research in 1958. Mr. Hazel joined Republic in 1940 as a ceramic engineer in Cleveland and subsequently was named chief ceramic engineer. He is chairman of the company's masonry committee.

Arthur K. Blough has been appointed chairman of Republic Steel Corp.'s open hearth and electric furnace committees. He succeeds **Robert P. Carpenter** as chairman of the open hearth committee and **Walter M. Farnsworth** as chairman of the electric furnace committee. Mr. Carpenter recently was named manager of Republic's Cleveland District steel plant, and Mr. Farnsworth has retired. A veteran of 26 years of service with Republic, Mr. Blough has been superintendent of the Open Hearth Department and the No. 2 and 3 melt shops at the Canton, Ohio, plant of Republic's Central Alloy District since 1944. He started with Republic at the Canton steel plant in 1934, as a metallurgist and was named plant metallurgist in 1936. He was appointed assistant superintendent of the plant's No. 1 and 2 melt shops in 1940 and assistant superintendent of the No. 3 electric furnace shop in 1941.

John J. Wyandt was named superintendent of the Open Hearth Department and No. 2 and 3 melt shops at Canton succeeding Mr. Blough. **John P. Rebillot** was named assistant superintendent of the Open Hearth Department and No. 2 and 3 melt shops, succeeding Mr. Wyandt. A veteran of nearly 36 years of service with Republic and its predecessor companies in Canton, Mr. Wyandt had been assistant superintendent since 1944. After starting his career in 1924, as a millwright, he served as heater helper, second and first helper in the No. 1 electric furnace shop and junior and senior melter. He was appointed assistant superintendent of the No. 1 shop in 1943 and spent four months that same year at Republic's Chicago plant while the plant's new electric furnace steelmaking facilities were being completed. Mr. Rebillot started his Republic career in 1926, as a laborer. He has been employed in the plant's No. 1 electric furnace shop since 1946, as third, second and first helper, melter and assistant superintendent of the shop.

Walter L. Scott, Jr., was appointed to superintendent and **Raymond L. Crowe** to assistant superintendent of The Youngstown Sheet and Tube Co.'s No. 3 Seamless Tube Mill at Indiana Harbor Works. Mr. Scott joined Youngstown in 1949 at the company's Campbell Works, Youngstown, Ohio, as an industrial engineer. He was promoted to junior industrial engineer and to industrial engineer then became a hot mill engineer in the Campbell seamless mill. He was transferred to Indiana Harbor in 1957 as assistant superintendent of the company's new seamless operation. Mr. Crowe came to Youngstown last February to become general foreman of the seamless mill. He was a turn foreman for the Mannesmann Tube Co., at Sault Ste. Marie, Ont., Canada.

Roger M. Wolcott has been appointed to the position of director of production planning programs for Jones & Laughlin Steel Corp. Mr. Wolcott succeeds **Howard E. Robinson,** who was named assistant to the president. In his new position Mr. Wolcott will coordinate J&L programs related to production planning, order processing, and inventory control. Mr. Wolcott joined J&L in 1938, as a trainee. He became a practice engineer at J&L's Pittsburgh Works in 1939. He since has held positions as special assistant superintendent of the Open Hearth Department, assistant superintendent of the Open Hearth Department, and superintendent of the Open Hearth Department, all at the Pittsburgh Works; and assistant works manager—

IRVING WHITEHOUSE

A. K. BLOUGH

J. J. WYANDT

W. L. SCOTT, JR.

G. H. TODD

G. H. YOST

W. B. BROWNING, JR.

C. G. KRAMER

project development, Cleveland Works. He was named assistant to the vice president—engineering and plant in 1959, and assistant director of production planning programs in February, 1960.

George H. Todd has been appointed assistant manager of Armco Steel Corp.'s Ashland, Ky., plant, and will be succeeded as general superintendent by **George H. Yost. Paul G. Sammet** was named assistant general superintendent in charge of melting operations and **John D. Patterson** becomes assistant general superintendent in charge of rolling and processing. **James W. Flowers** has been promoted to assistant general superintendent in charge of plant services. **William O. Richmond** was appointed superintendent of the Open Hearth Department and **Austin M. Henderson** has been promoted to superintendent of the plant's East Processing Department.

Mr. Todd joined Armco in 1928. He served as blast furnace superintendent and open hearth superintendent and became general superintendent of the Ashland Works in 1957. Mr. Yost began his Armco career in 1925. After a variety of assignments in both production and personnel work he became assistant general superintendent in 1953. Mr. Sammet joined Armco in 1929. He became a senior metallurgist at the Ashland plant in 1940 and open hearth superintendent in 1947. Mr. Patterson has been with Armco since 1928. He was made works industrial engineer in 1936, and superintendent of the East Processing Department in 1954. Mr. Flowers joined Armco in 1933. Following a variety of engineering assignments he was made assistant superintendent of the Maintenance Department in 1946. Mr. Richmond, after 16 years in the melting operations at the plant, was made assistant superintendent of the Open Hearth Department in 1947. Mr. Henderson began his Armco career in 1939. He was made assistant superintendent of the Coating Department at the Ashland Works in 1957.

Ward B. Browning, Jr., has been named assistant chief engineer of the Armco Division, Armco Steel Corp. He will be succeeded as assistant works engineer of the Butler, Pa., Works by **Charles G. Kramer.** Mr. Browning joined Armco at Middletown, Ohio, in 1946 as an engineering draftsman. He was made an electrical engineer in 1947, senior electrical engineer in 1951 and project engineer in 1956. In 1957 he was transferred to the Butler Works as assistant works engineer in charge of development and construction. Mr. Kramer joined Armco at the Middletown Works and was made an engineering draftman in 1946. He was advanced to electrical engineer in 1947 and senior electrical engineer in 1952. He served on special assignment with the Armco International Corp., in France, in 1954. He returned to his position as senior electrical engineer in 1955.

Charles A. Porter was appointed chairman of Republic Steel Corp.'s company-wide blooming mill committee. Associated with the steel industry for the past 44 years, Mr. Porter began his career in the Blooming Mill Department of the old Corrigan-McKinney works in 1916. Since that time he has held various blooming mill positions prior to his appointment as superintendent in 1948.

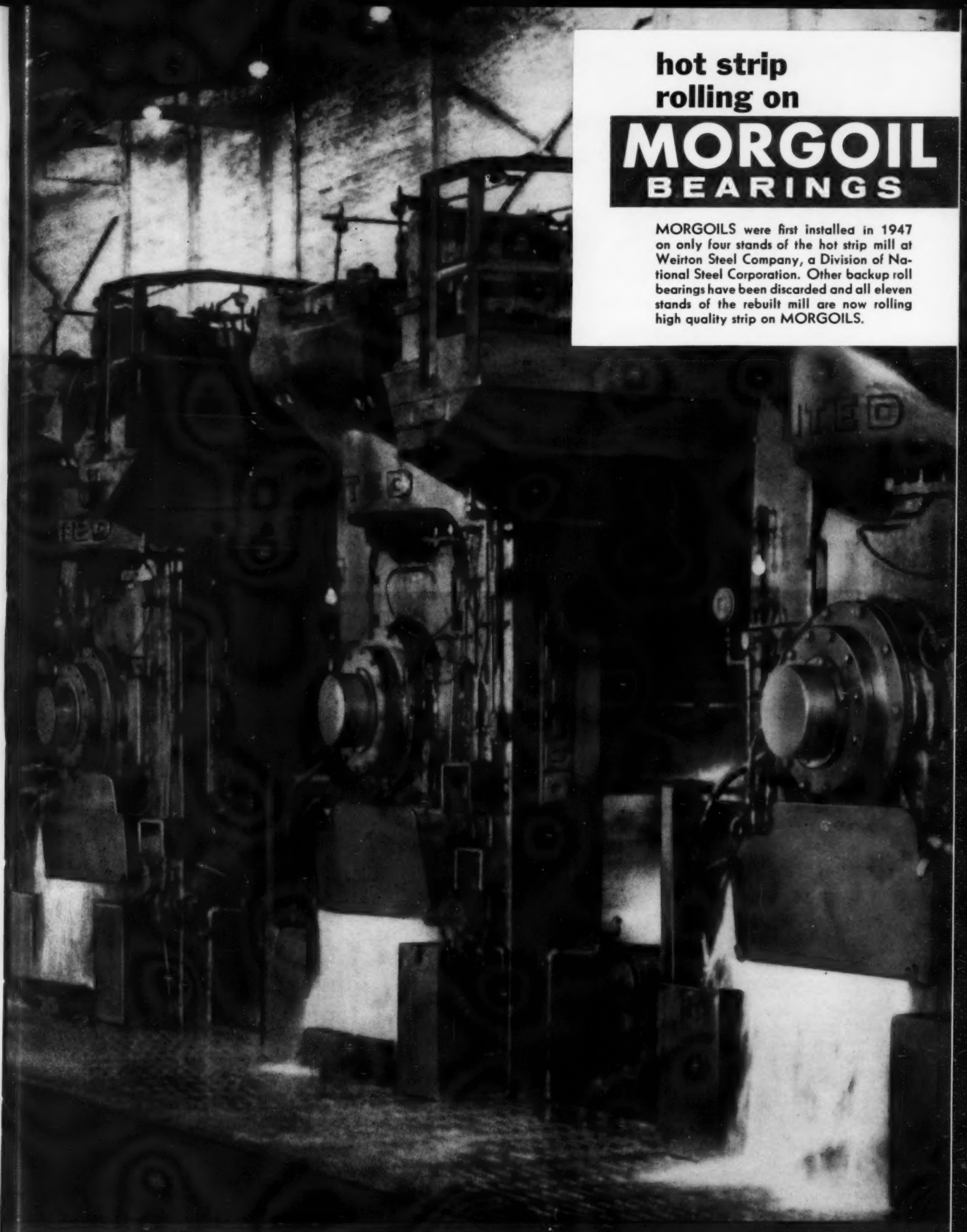
George Havas has been appointed vice president and director of engineering of Kaiser Industries Corp. Associated with the various Kaiser companies since 1928, Mr. Havas served as chief engineer of Henry J. Kaiser Co. after 1935 and became vice president of the company in 1945. In 1958 he assumed the position of general manager of the company's Heavy Construction Division and the international subsidiaries.

Joseph W. Lodge has been named staff research engineer in charge of coordinating research projects of The Youngstown Sheet and Tube Co. Formerly with Crucible Steel Co. of America and Battelle Institute, Mr. Lodge started his steel career with Wheeling Steel Corp. as a mill metallurgist.

M. W. Saxman has resigned as president of Latrobe Steel Co. but will continue as chairman of the board.

M. W. SAXMAN

J. E. WORKMAN



hot strip rolling on MORGOIL BEARINGS

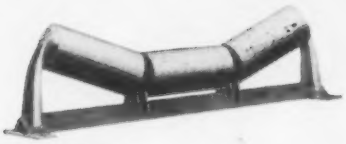
MORGOILS were first installed in 1947 on only four stands of the hot strip mill at Weirton Steel Company, a Division of National Steel Corporation. Other backup roll bearings have been discarded and all eleven stands of the rebuilt mill are now rolling high quality strip on MORGOILS.

MORGAN CONSTRUCTION CO., WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • GAS PRODUCERS
WIRE MILLS • EJECTORS • REGENERATIVE FURNACE CONTROL

MB 35

SERIES 5000
For intermittent operation . . . relatively low capacity.



SERIES 6000
For continuous operation . . . moderate capacity.

759 ways to solve your idler problems

Link-Belt idlers in standard types and sizes to meet every conceivable belt conveyor need

You're sure to find the exact idler to perfectly match your belt conveyor requirements from the complete Link-Belt line of 759 types and sizes.

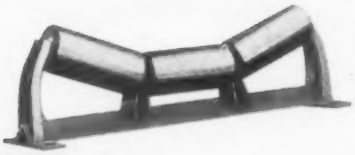
This broad line enables you to select a size idler that exactly matches your needs, no over- or under-engineering. Power requirements are held to a minimum. In addition, anti-friction bearings, accurate roll alignment and rugged construction provide maximum life for idlers and conveyor belt in light- or heavy-duty service.

Link-Belt idlers are available with end rolls inclined at 20°, 35° and 45° for a broad range of belt widths. Matching lines of troughed belt rubber cushion, troughed belt training, return belt and rubber tread return belt idlers are also available. Call your nearest Link-Belt office or authorized stock-carrying distributor for full details. Look for CONVEYORS in the yellow pages of your phone book. Or write for Book 2716.

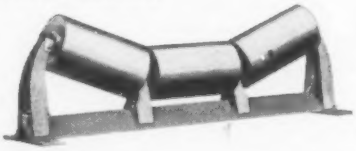
LINK-BELT

BELT CONVEYOR IDLERS

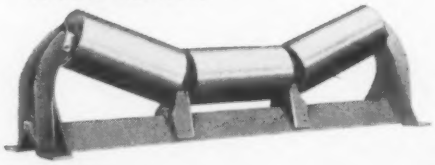
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,407



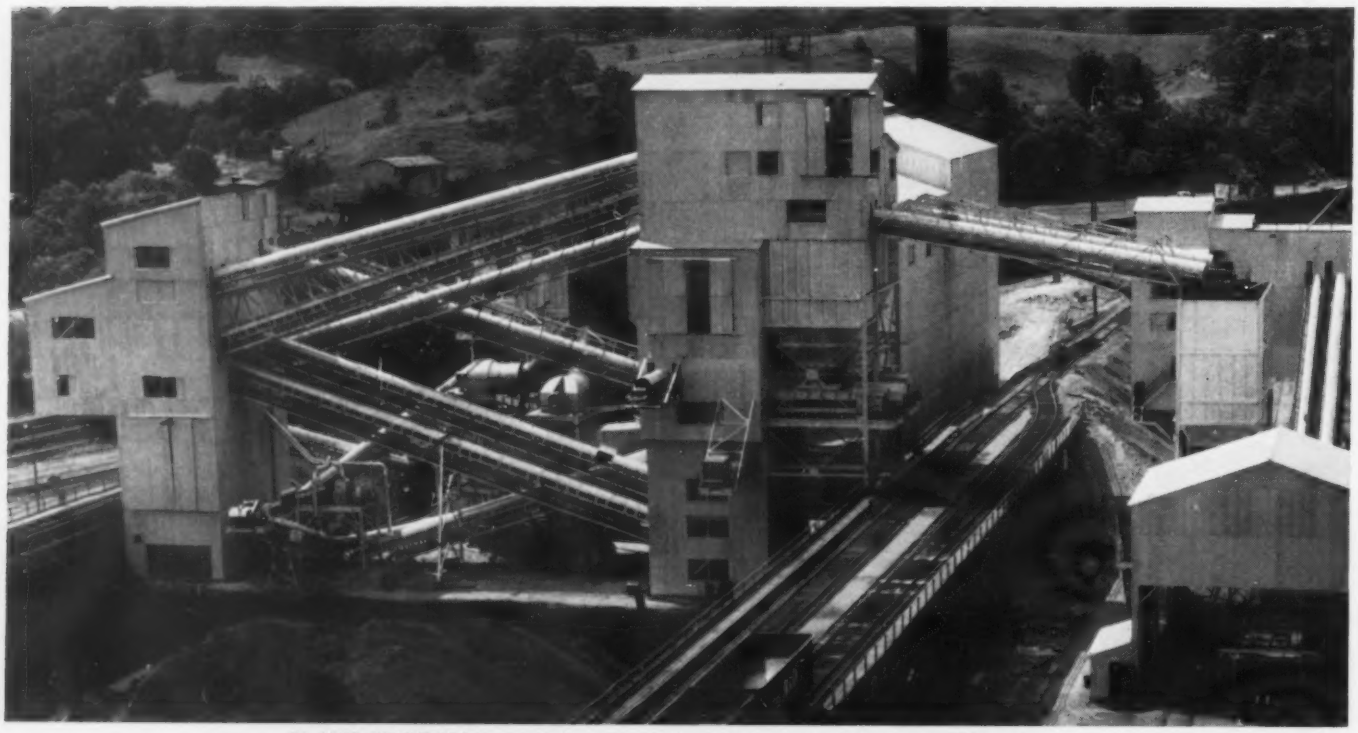
SERIES 7000
For continuous operation, higher capacities, heavyweight, abrasive materials.



SERIES 8000
For continuous operation, higher capacities, heavier-weight, abrasive materials.



SERIES 9000
For continuous service, highest capacities, heaviest and coarsest materials.



50 BELT CONVEYORS, employing five different sizes of various type idlers, keep raw materials moving steadily through this sintering plant of Armco Steel.

W. A. MORTON

WALTER SUYDAM

H. T. FLORENCE

C. F. SAFREED

J. E. Workman, executive vice president was named to the presidency, succeeding Mr. Saxman.

William A. Morton has been elected chairman of the executive committee in charge of foreign operations, Loftus Engineering Corp., and **Walter Suydam** has been elected president of the corporation.

Herbert T. Florence, who started with the company as an apprentice 37 years ago, has been elected president and general manager of The Cleveland Crane & Engineering Co. He succeeds **Charles F. Safreed** who has been made chairman of the board. Also advanced were **William J. Ryan,** who became vice president and assistant general manager; and **Ralph Ford,** plant superintendent, who was made assistant secretary, in addition to his present position.

Robert L. Myers has been appointed a supervising research metallurgist for Armco Steel Corp. He succeeds **Dr. J. J. Canfield,** who has retired after 32 years with Armco. He will continue to serve the company as an enameling consultant. Mr. Myers joined Armco in 1939. After an assignment in the metallurgical laboratory at the Middletown Works, he moved to the Research Center in 1941 as an analyst. In 1946 he was promoted to research engineer and became a senior research engineer in 1951.

Fred B. O'Mara has been named vice president—production of National Carbon Co., division of Union Carbide Corp. Mr. O'Mara has been director of manufacturing for National Carbon since early this year. Previous to that he was marketing manager of electrode products. He joined Union Carbide in 1936.

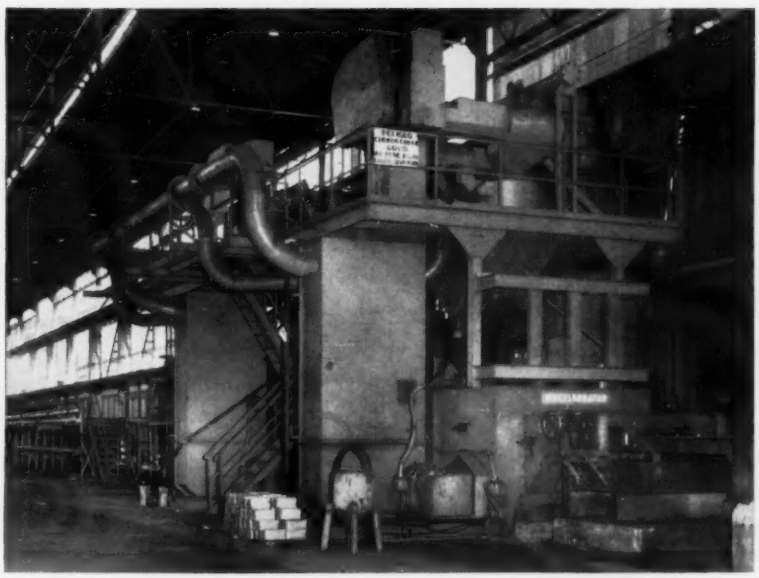
EXECUTIVE REPORT #11

HERE CARBON STEEL SHEDS ITS SCALE

Wheelabrator® Descaling Enables 100% Increase in Production

Every ton of steel produced in the modern mill of Altos-Hornos De Mexico, S.A., at Monclova, Coahila, is run through a Wheelabrator airless blast descaling cabinet. In a typical month, over 15,500 tons of carbon steel from a hot Steckle reversing type mill was Wheelabrator descaled followed by a light pickle rinse. The end product is reduced on reversing cold mills for sale as cold rolled steel, tin plate, and galvanized stock.

Steel is descaled in this new line at a rate of up to 200 f.p.m. contrasted to a speed of only 100 f.p.m. when acid pickling was used exclusively for descaling. Even with this increase in production, acid consumption has been cut in half and overall descaling costs materially reduced.



Wheelabrator Engineering Experience At Your Service

Write today for information on how Wheelabrator descaling can cut your costs and speed production. Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P.O. Box 490, Scarborough, Ontario.

WHEELABRATOR
AIRLESS BLAST EQUIPMENT

M. W. Burleson has been appointed a general sales manager in Johns-Manville Corp.'s Industrial Insulations Division. He succeeds **J. B. Jobe,** who became general manager of one of three J-M operating divisions. Mr. Burleson began his career with Johns-Manville at Chicago in 1936 as assistant district engineer and was subsequently appointed assistant manager for insulations. In 1950 he was transferred to division headquarters at New York as a staff manager and has held other executive posts in marketing and selling. He was appointed general product manager and elected a vice president of Johns-Manville Sales Corp. in January, 1960. He remains a vice president with the assumption of his new duties.

L. W. Nash has been named chairman of the board, L. W. Nash Co. At the same time, **T. W. Nash** was named president, and **R. U. Nash,** executive vice president and treasurer.

Vincent R. Troglione has been elected president of Sunbeam Equipment Corp., succeeding **H. C. Gwinn,** who has been named chairman of the board of directors. Mr. Troglione was vice president and general manager of the Meadville Industrial Furnace Co. before becoming its president.

Walter M. Farnsworth, assistant manager of Republic Steel Corp.'s Central Alloy and Chicago steel districts, has retired. He started as a chemist in 1914 at the Carnegie Illinois Steel Co.'s South Works in Chicago. He joined the Timken Roller Bearing Co. in Canton, Ohio, in 1919 as a melter in the company's Electric Furnace Department. In 1925 he joined Republic's predecessor company in Canton, United Alloy Steel Corp., as superintendent of the Electric Furnace Department. He retained this position through the mergers which formed Central Alloy Steel Corp. and later Republic Steel in 1930. In 1938, he was appointed superintendent of Republic's Canton steel plant. Mr. Farnsworth was named assistant district manager in charge of electric furnace operations for both Republic's Central Alloy and Chicago steel operations in 1946. He also has served as chairman of the company's electric furnace committee and representative to the corresponding committee of the American Iron and Steel Institute.

Joseph F. Degen has been named vice president and general manager of Daystrom, Inc., Weston Instruments Division. **Edward L. Klein** succeeds him as vice president, operations, of Weston Instruments Division.

Glenn V. Prible has been appointed assistant chief engineer of the Rust Furnace Co. He has had six years of service with Rust in design engineering work of various types of industrial furnaces for the steel and aluminum industries.

William C. Keeley has been elected chairman of the board of directors of Vanadium Corp. of America, and he has been succeeded as president by **George LaMonte Weissenburger,** previously vice president. **George C. Floyd** has been named senior vice president. Mr. Keeley, who became president of the company in 1949, and who since 1936 has been a member of the board of directors and a member of the executive committee, remains chief executive officer. Mr. Weis-

EXECUTIVE REPORT #12

A PIPE DREAM COMES TRUE

Wheelabrator® cleans skelp edges at new low cost

Another example of steel industry savings made possible by Wheelabrator mechanical descaling is the exceptional economy realized by pipe rolling mills in cleaning of skelp. Here it is desired to clean only a small strip along both edges of the bottom side of the skelp, which will be butted together and electro-welded.

In the Wheelabrator process, two blasting wheels are positioned to pinpoint their abrasive barrage along the edges, giving fast, thorough cleaning of these surfaces only.

Wheelabrator leads in mechanizing steel mill descaling methods

In over 100 installations in all types of steel mill applications, Wheelabrator has proven its cost-saving benefits. For engineering consultation call or write Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P. O. Box 490, Scarborough, Ontario.

K. E. ATWOOD (left)
P. B. SMITH (center)
L. F. MONAHAN (right)

senburger was elected a director and vice president in 1959, following the merger of Keokuk Electro-Metals Co. into the corporation. Since 1937 he had been president and treasurer of the Keokuk company. Mr. Floyd has been associated with Vanadium as vice president since 1951. He was elected a director in 1952.

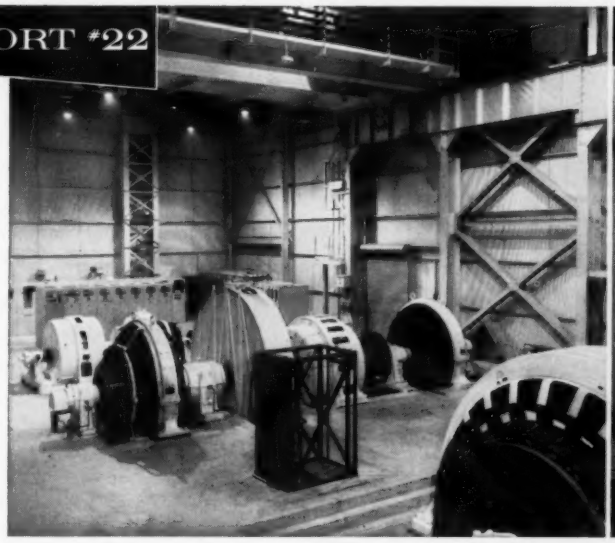
K. E. Atwood has been named manager of the Pittsburgh district of Bailey Meter Co. Two other new district managers were announced: **P. B. Smith,** Seattle; and **L. F. Monahan,** Denver. Mr. Atwood joined Bailey in 1937. He worked on the Boston staff until 1948, when he was appointed manager of the Seattle district, the position he held prior to his present appointment. He succeeds **H. R. Fulton** who has been appointed a regional manager. Mr. Smith started with Bailey in 1946. Prior to his present appointment he had been resident engineer in the Portland Office, subdivision of the Seattle district. Mr. Monahan joined the company in 1948, worked in the Contract Engineering Department for 18 months, and was assigned to Denver in 1950. In 1953 he was appointed resident engineer in Salt Lake City, and held this position until his present assignment. He succeeds **A. L. Danielsen** who has been named a regional manager.

Dr. Eugene W. Boehne has joined the engineering staff of the I-T-E Circuit Breaker Co. In his capacity as consulting engineer—research and development, Dr. Boehne will assist and advise the I-T-E engineering staff in establishing a unified program to advance corporate research and development. Dr. Boehne has been professor of electrical engineering at the Massachusetts Institute of Technology and administrator of its cooperative course in electrical engineering since 1947. Prior to that he worked for the General Electric Co.

EXECUTIVE REPORT #22

NO ROOM FOR DUST

In Acme Steel's New Blooming Mill Motor Room



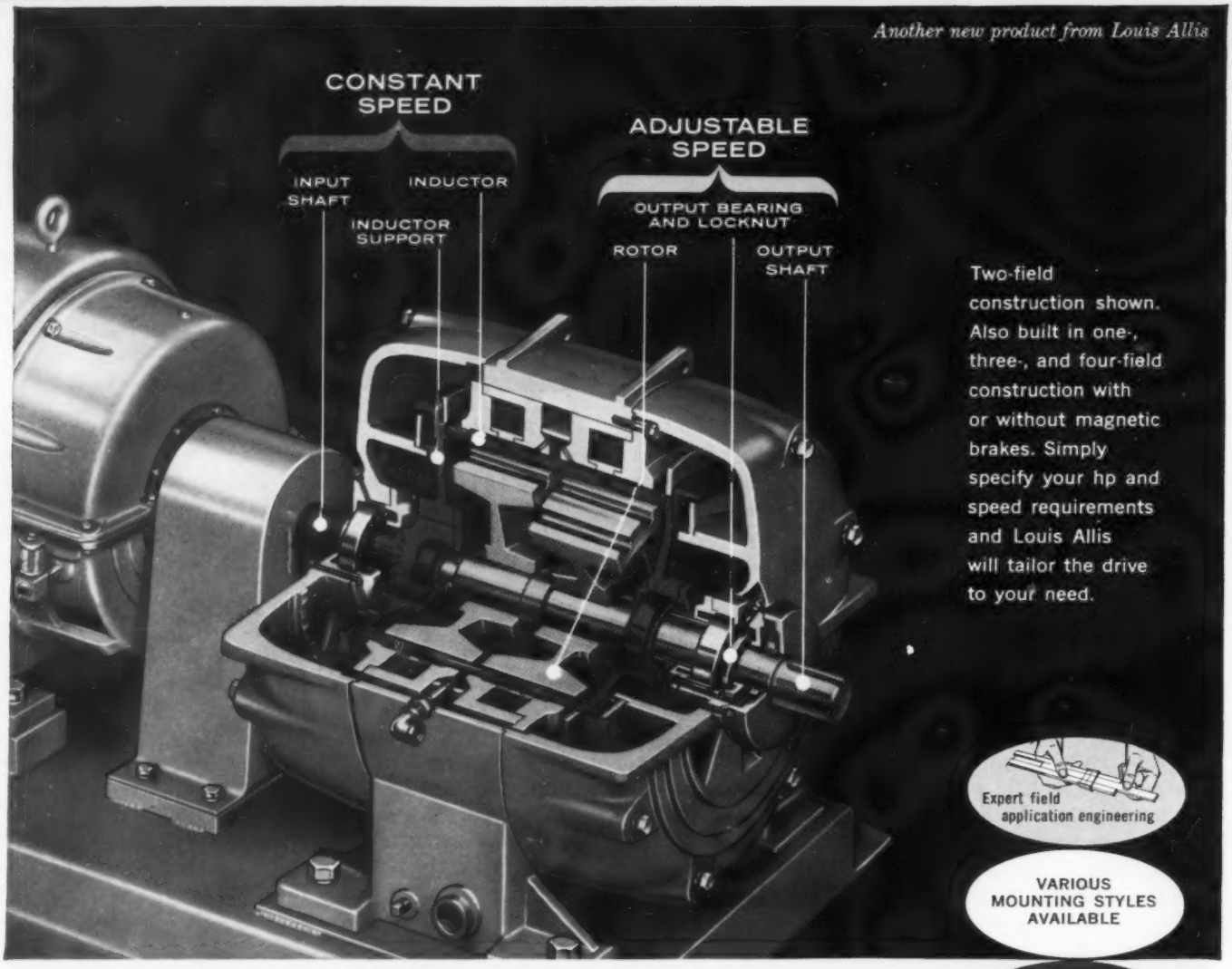
Even the air you breathe isn't pure enough to meet the demands for air to ventilate the motors and generators in Acme Steel Company's new Riverdale, Ill. plant. Wheelabrator Ultra-Filtration® provides air that is ultra-pure for the exacting requirement of their blooming mill motor and control room. Furnishing 135,000 cfm of super-filtered air, this installation has been functioning with absolutely no maintenance, and no filter change since its installation in 1959.

FILTRATION EFFICIENCES OF 99.9% ARE FREQUENTLY ACHIEVED BY WHEELABRATOR

Ultra-Filtration equipment provides filtration efficiencies of above 99%, measured both by weight and discoloration. For details of this economical air filtering equipment write to Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, P. O. Box 490, Scarborough, Ont.

WHEELABRATOR
DUST AND FUME CONTROL

Another new product from Louis Allis



Two-field construction shown. Also built in one-, three-, and four-field construction with or without magnetic brakes. Simply specify your hp and speed requirements and Louis Allis will tailor the drive to your need.

Expert field application engineering

VARIOUS MOUNTING STYLES AVAILABLE

The new Louis Allis MAGNETIC DRIVE

A compact, adjustable speed drive up to 2000 hp!

Based on a liquid-cooled magnetic coupling design, the *all-new* Louis Allis Magnetic Drive offers you the finest in precise regulation, compactness, and design flexibility for adjustable speed drives up to 2000 hp.

A unique annular cooling manifold provides effective heat transfer. It eliminates "water-drag" since there is *no* liquid in the air gap between the constant-speed and adjustable-speed members. There's no "flooding" the Magnetic Drive or forcing of water into bearings. And you'll *never* find condensation in the bearings. The reason: a planned flow of air through the drive reduces bearing temperatures and exhausts any condensation which might occur as the unit cools off after use.

Stationary field construction eliminates slip rings. All bearings can be lubricated without disassembly, and grease chambers provide ample grease reservoirs. Coils and lead connections are encapsulated in a chemical- and heat-resistant polyester — and simplified construction eases inspection and servicing. The *all-new* design permits simple relocation of cooling inlet, conduit box, discharge, etc., regardless of direction of rotation.

If your plans call for adjustable speed drives — specify Louis Allis Adjustable Speed Magnetic Drive. Write for a copy of Bulletin 3650 — now available at your Louis Allis District Office, or from The Louis Allis Co., 450 E. Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

ASD-135

W. M. Terry, Jr., has been named general manager, electrical departments, Allis-Chalmers Manufacturing Co.'s Industrial Equipment Division. Mr. Terry, director of engineering coordination for Allis-Chalmers Industries Group since 1957, is now responsible for the operations of Norwood, Ohio, Works, including the electrical and pump departments there, and the control and industrial systems departments, and the rectifier section at the West Allis Works. He joined Allis-Chalmers in 1947 as a development engineer. In 1952 he was named assistant chief engineer at Pittsburgh Works and in 1956 he became chief engineer there.

R. C. Conover was named general works manager, Refractories Division, H. K. Porter Co., Inc. Mr. Conover was previously Western district works manager for the Refractories Division.

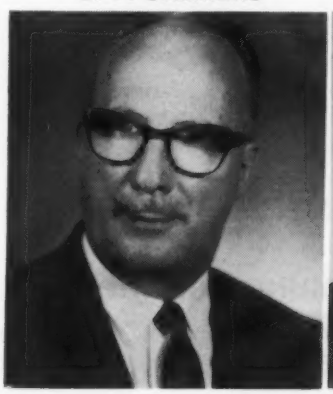
J. W. Pinks was appointed Manager, Administrative Department, Engineering and Construction Division, Koppers Co. Inc. Since 1956, Mr. Pinks has been manager, sales service in the International Division. He first joined Koppers in 1942, and has served in a number of engineering and administrative positions in the Engineering and Construction, and International Division.

William D. Jameson has been named manager of the Buffalo, N. Y., district sales office of I-T-E Circuit Breaker Co. He will handle sales of I-T-E electrical equipment in western New York and northwestern Pennsylvania. Mr. Jameson has been recently engaged in consulting work in Miami, Fla. Prior to that, he had served as I-T-E's eastern regional manager for six years.

Charles F. Simmers has been named chief engineer of the Engineering and Construction Division of Koppers Co., Inc. He succeeds **A. B. Fisher, Jr.,** who was recently appointed to a major overseas assignment. Mr. Simmers has been assistant chief engineer since joining Koppers in 1959. He was formerly associated with Morgan Engineering Co., United Engineering and Foundry Co., and United States Steel Corp.

Richard P. Krause has been named chief engineer of Pennsylvania Engineering Corp. **A. C. Kohnfelder,** formerly chief engineer, has been appointed to the newly created post of assistant to the vice president of engineering. Mr. Krause was formerly with Pittsburgh Steel Co. He also has headed his own engineering firm, and has worked in various capacities with Ankerson

C. F. SIMMERS



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Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.
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A. J. SMITH

C. R. ROEHRER

Engineering Co., The Teller Co., Armco Steel Corp. and United Engineering and Foundry Co.

Albert J. Smith has been named vice president of The McKay Co. Mr. Smith is in charge of Electrode Division sales. After a number of years in the Metallurgical Department of Jones & Laughlin Steel Corp., he joined McKay in 1949 and has held various technical and sales positions. In 1955, he became sales manager of the Electrode Division.

Carl R. Roehrer has been named sales manager of The Euclid Electric & Manufacturing Co. He was formerly manager of application engineering and also participated in development and research of new products. **William E. Feil,** who has been assistant manager of application engineering, assumes the duties of manager of application engineering. Mr. Feil joined Euclid Electric in 1958.

William Brenner, Jr., has been appointed service metallurgist at the Louisville, Ohio, plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division. He was formerly research engineer at the Youngstown, Ohio, plant. **Lowell Steinbrenner,** was named development engineer for the Youngstown and Louisville, Ohio, plants. He was a research engineer in the Stainless Steel section of Jones & Laughlin's Graham Research Laboratories.

Charles D. Shickley has been appointed manager of technical sales for Northeast Ohio Machine Builders, Inc.

Robert L. Reed was named general sales manager for Union Carbide Metals Co., division of Union Carbide Corp. He joined Union Carbide Metals in 1946 as a technical and service representative in Chicago, Ill. Prior to his new appointment, Mr. Reed served as manager of Union Carbide Metals' Detroit, Mich., district, and manager of the Pittsburgh, Pa., region since 1957. Before joining Union Carbide Metals, he had been associated with the United States Steel Corp.

Edward J. Keck was appointed superintendent of steel conditioning at Republic Steel Corp.'s Canton, Ohio, steel plant. He succeeds the late **E. D. (Butch) Gibson**. At the same time, **Arthur W. Shaw** was named

CORRUGATE SHEETS with a

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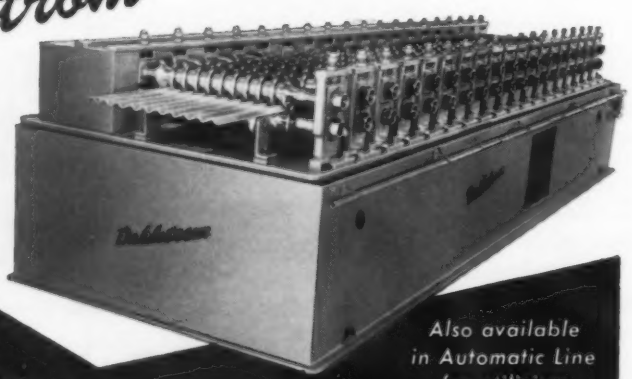
ROLL FORMING MACHINE



FEATURING:

- All welded construction.
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Also available in Automatic Line for utilizing coil stock.

Major Building Products Manufacturers use this setup for corrugating 20 through 28 gauge galvanized steel, plain and embossed aluminum.

Requires only vertical adjustment for gauge range. Roller die tooling available for various depths. Excellent control of coverage and depth. No length restrictions.

Other gauge ranges also available. Send complete detailed specifications for quotation.

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- **SLIDING DIE-TYPE CUT-OFF PRESSES**
- **COIL REELS**
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- **ROLL STRAIGHTENERS**
- **PRESS FEED EQUIPMENT**
- **DECOILING AND SHEARING LINES**

•

to succeed Mr. Keck as assistant superintendent of steel conditioning at the Canton plant. Mr. Keck has been with Republic at the Canton steel plant for 20 years. He started in 1940, as a foreman and was named turn foreman in 1946. He has been assistant superintendent of steel conditioning since 1947. Mr. Shaw has been with Republic at the Canton plant for 27 years. He started as a piler and loader helper in 1933 and was appointed foreman 10 years later. He has been a turn foreman since 1947.

R. P. Stuntz has been named manager of field sales and **L. D. Christie, Jr.,** named product manager, technical sales, of The Babcock & Wilcox Co.'s Refractories Division. Joining B&W in 1940, Mr. Stuntz served as a plant engineer in the company's Augusta, Ga., works and was named assistant Chicago district sales manager in 1950. He was appointed Chicago district manager the following year, a post he held until named assistant sales manager in 1957. Mr. Christie joined B&W's Refractories Division in 1940 as a research engineer and was named assistant to the division's technical director in 1945.

Lars Ekholm has been appointed vice president of Eastern operations of the Climax Molybdenum Co., a division of American Metal Climax, Inc. In his new post, Mr. Ekholm will be responsible for the production of Molybdenum products. Prior to his appointment, he was general sales manager of Climax Molybdenum. He was associated with Alan Wood Steel Co. before joining Climax Molybdenum in 1946.

Joseph P. Hensel has been named manager, machinery sales, of the Pennsylvania Crusher Division, Bath Iron Works Corp. Mr. Hensel has been with the Sales Department of Pennsylvania Crusher Division since 1950, most recently as district sales representative in the St. Louis, Mo., territory.

Robert S. Kocourek has been promoted to the newly created position of manager, manufacturing services, of Foote Bros. Gear and Machine Corp. Mr. Kocourek previously was factory manager, Plant No. 1, for Foote Bros. In his new post, he will coordinate manufacturing functions of all three Chicago area plants, reporting directly to the vice president of manufacturing. **Herbert V. Cork** has rejoined Foote to replace Mr. Kocourek as factory manager, Plant No. 1. For the past two years, Mr. Cork has been planning manager for Solo Cup Co. Prior to that he was a project engineer for Foote Bros.

Joseph F. Rigler has been named sales engineer for the mid-Atlantic States by Mead-Morrison Division, McKiernan-Terry Corp. Prior to joining Mead-Morrison, Mr. Rigler was with Sinclair Refining Co.

Obituaries

Eugene Gifford Grace, honorary chairman of Bethlehem Steel Corp. since 1957, died July 25. He was 83. A leader in the steel industry for more than a half century, Mr. Grace began his long career with Bethlehem in 1899 as an electric crane operator. He was appointed general manager of the company in 1908, with general supervision of all manufacturing, sales, and purchases. He became a director of the corporation in 1911. He was made president of Bethlehem Steel Co. in 1913, at the age of 36, and became president of Bethlehem Steel Corp. in 1916. After long serving as Bethlehem's chief executive officer, he was named chairman in 1945. He served as president of the American Iron and Steel Institute, 1935–1936. In 1957, he was elected an honorary vice president of the Institute.

William J. Reilly, general manager, Steel Mill Div., Ford Motor Co., Detroit, Mich., died July 11. Mr. Reilly had been active over the past several years in the Detroit District Section of the AISE, and was chairman in 1950–1951.

Jonathan Jones, retired chief engineer of the Fabricated Steel Construction Division, Bethlehem Steel Co., died June 25. He was 78.

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Slitting and Coiling Lines
Cut-to-Length Lines
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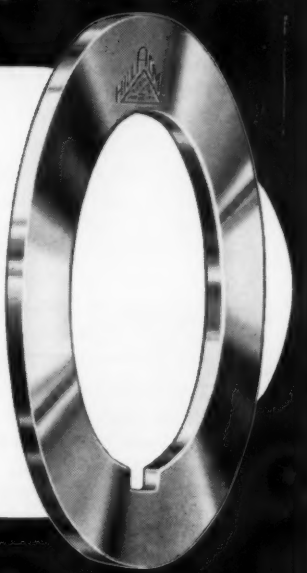
Power Squaring Shears • Automatic Resquaring • Corrugating
Culvert • Steel Mill Equipment

STAMCO, Inc., New Bremen, Ohio

"CLEVELAND"

Rotary Slitting and Side Trimmer Knives



It's the quality of the tool steel plus 40 years of "Know How" that insure CLEVELAND KNIFE users of complete satisfaction. "CLEVELAND" Knives are made in "Alloy", "Century", "Peerless" and "High Speed" grades to meet every metal cutting condition.

HILL ACME TOOLS FOR INDUSTRY

THE HILL ACME COMPANY
CLEVELAND KNIFE DIVISION
6402 Breakwater Ave., Cleveland 2, Ohio

National builds lifting magnets to stay in service.

The coils are *monolithic*, triple insulated and bonded with high-temperature, void-free resin.

They're watertight to prevent moisture reaching the coils. The plate is anchored to the magnet case with continuous welds around inner and outer edges.

They're rugged to withstand severe heat cycling and shock.

Check National for your lifting magnet requirements. For more information call Columbus plant... HUdson 8-1151... or the nearest National field engineer.

The Specialists in electric coils/repair service

National repairs magnets of any origin, size or shape.

Average Hot Lifting Capacity	55" Pounds	65" Pounds
Slabs, billets	53000	68000
Skull cracker balls	23000	38000
Machine cast pig	3000	3700
No. 1 heavy melting steel scrap	3200	3500
No. 2 melting steel	2000	3500
No. 1 machinery scrap (cast iron)	1700	2400
Cast iron borings	1700	2400
Steel turnings	1000	1200

NATIONAL COILS

National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY • COLUMBUS 16, OHIO

Electrical Engineers • Manufacturers of Electric Coils, Insulation, Lifting Magnets

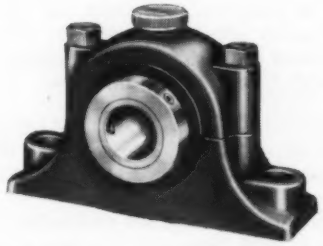
Redesigning and Repairing of Rotating Electrical Machines

McGRAW EDISON

Photo courtesy of McDowell Co., Inc.

Dodge dependability built into new sinter plant conveyor system at Inland Steel

DODGE TAPER-LOCK STEEL CONVEYOR PULLEYS



DODGE DOUBLE INTERLOCK PILLOW BLOCKS WITH TIMKEN BEARINGS

Dodge Taper-Lock Steel Conveyor Pulleys and Dodge Double Interlock Pillow Blocks with Timken Tapered Roller Bearings contribute their dependability to this new sinter plant. They are an important part of the extensive conveyor system engineered by Dwight-Lloyd Division of McDowell Company, Inc., Cleveland.

Maximum strength with minimum weight is provided by these rugged conveyor pulleys. Their steel rims, discs and hubs are fused together into jointless drum construction for terrific impact resistance. With the unsurpassed holding power of Taper-Lock mounting there is no "walking on the shaft."

Dodge Double Interlock Pillow Blocks (with Timken Tapered Roller Bearings) were chosen for this hard service. They are rugged, compact, fully self-aligning—with substantial radial and thrust capacities. The extra long inner race distributes load over a greater shaft area. They are adjusted, lubricated and sealed at the factory—for a long life of dependable service.

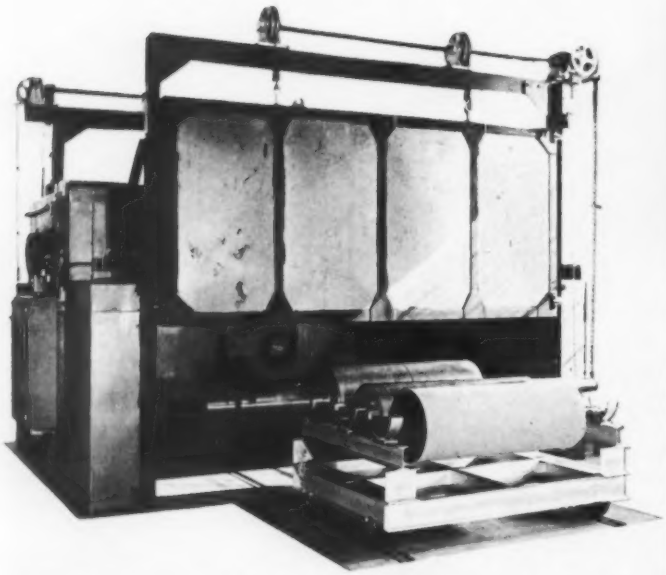
DODGE MANUFACTURING CORPORATION, 5900 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Equipment."

„ . . die besten Walzen für die heutige Stahl-industrie "

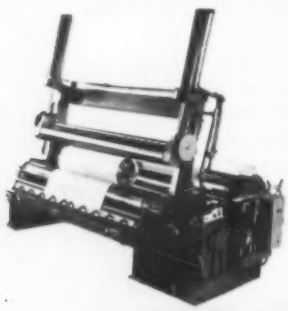


A combination of German craftsmanship and American ingenuity have, through Joseph Zimmermann, solved a problem suffered by the steel industries all over the world.

THE PROBLEM: conventional rollers on continuous electrolytic lines, galvanizing lines and annealing lines have a tendency to pick up bits of metal which mark the steel: they have to be continually watched, constantly cleaned, and far too often replaced—resulting in a waste of valuable production time and money.

THE SOLUTION: a new laminated *plastic coated* roller developed by Mr. Zimmermann of the Steel Plant Equipment Corp. With the precise care of German craftsmanship, and American equipment built to his specifications, Mr. Zimmermann can make these rolls from all the Nema Grade types of materials or any special grades specified by prospective customers and in sizes from 4" to 36" in diameter and up to 96" long.

These new plastic coated rollers have been proven by the steel industry all over the world to last from three to five times as long as the previous types of rollers, and to cut down-time to a minimum. As Mr. Zimmermann sums them up: these plastic covered rollers are . . . "the best rollers for the steel industry today."



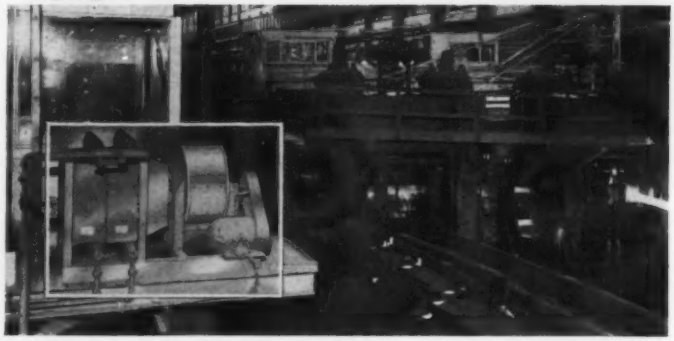
STEEL PLANT EQUIPMENT CORP.

Wilson Blvd. & Ridge Pike, Eagleville, Pa. BRoadway 5-7539

PROBLEM!

Prevent

OIL AND WATER LINE FREEZING AT GROUND LEVEL AROUND ROLL STAND FOOTINGS.



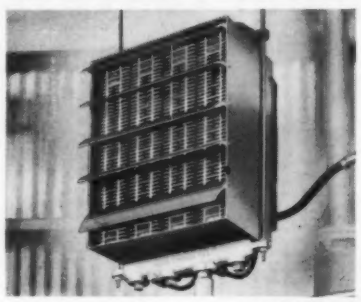
One of Three Grid High Velocity Blower Units installed in Inland Steel's Plant #2-28" Mill Building.

SOLUTION!

GRID HIGH VELOCITY HEATING UNITS consisting of all cast iron Blast Heaters with belt driven, high speed blower. These special units operate on 150 P.S.I. steam pressure at 450 degree Fahr. temperature. Air is raised from 10 to 20 degrees at inlet side to 150 degrees at discharge. Air discharge nozzles located below the platform force heated air in downward, angular direction to ground level. Air velocity 2500 to 2700 F.P.M. Air volume 4100 C.F.M.

PROBLEM!

USE STEAM FOR COMFORT HEATING THROUGH UNIT HEATERS IN SINTERING PLANT. STEAM SERVICE 225 P.S.I. PRESSURE REDUCED TO 75 P.S.I., 600 DEGREE TEMPERATURE WITH 300 DEGREE SUPER HEAT.



One of 62 High Test Cast Iron Grid Unit Heaters installed in Inland Steel's Sintering Plant, East Chicago, Ind.

SOLUTION!

GRID special alloy HIGH TEST cast iron Unit Heaters. Alloy iron heating elements and top and bottom headers designed to withstand 75 P.S.I. steam pressure with 300 degree super heat. All parts subject to pressure are made for maximum of 225 P.S.I., in event reducing valves fail. Motors are equipped with special insulation and heat stabilized bearings. Fans are arranged with heat shields to reflect radiant heat.

FOR MAINTENANCE FREE HEATING SERVICE AND FOR THAT DIFFICULT STEEL MILL HEATING PROBLEM, SPECIFY GRID CAST IRON UNIT HEATERS, BLAST HEATERS AND RADIATORS.

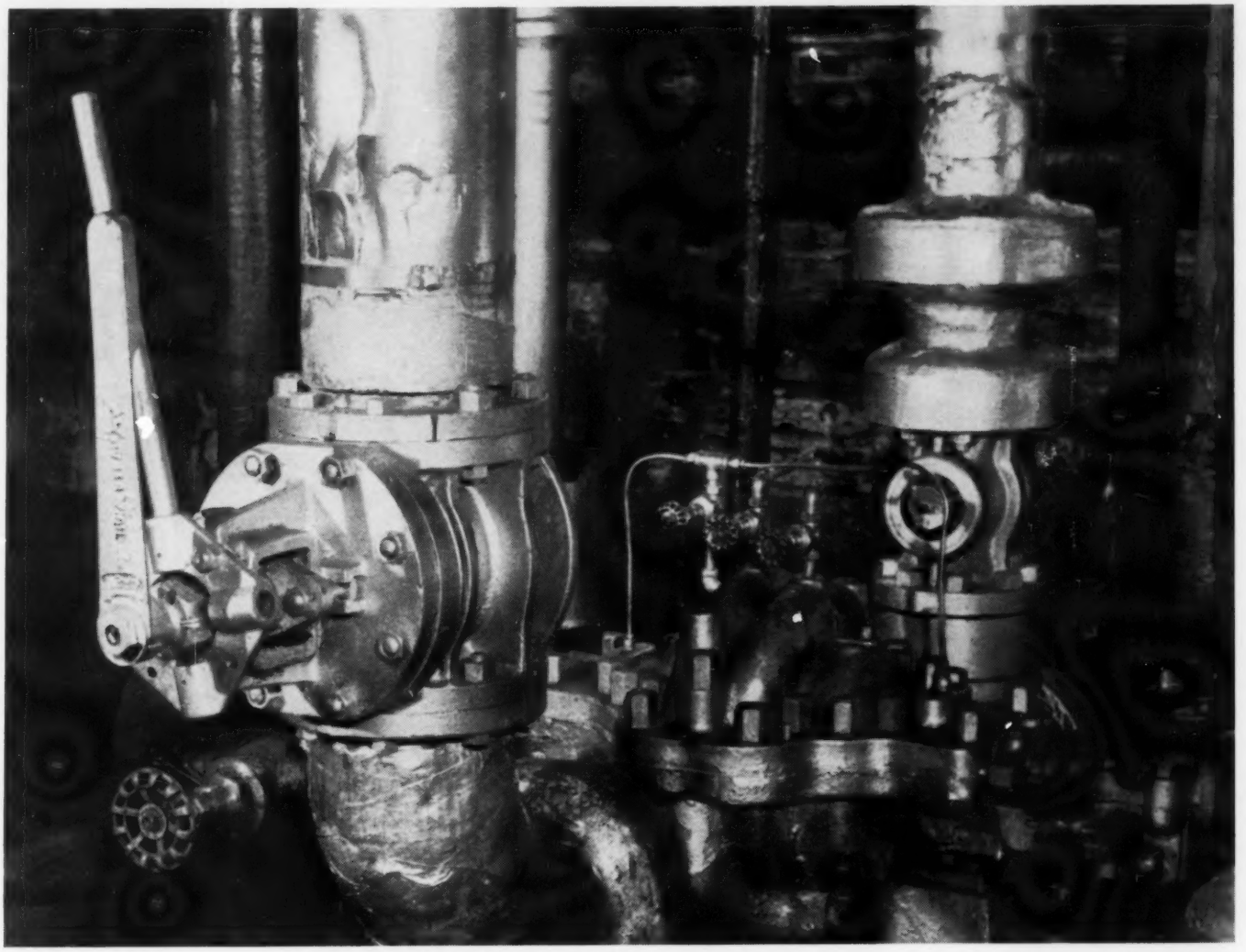
Engineering consultation service without obligation. Write for catalog 956, the complete Grid Story.

Manufacturers Since 1883

GRID D. J. MURRAY MANUFACTURING CO.

WAUSAU, WISCONSIN

STICK-PROOF OPERATION EVERY TIME with Homestead® Lever-Seald Quarter-Turn Plug Valves. Homestead's powerful lever and screw principle assures positive action . . . even under the most severe



temperature, pressure and fluid conditions. It also guarantees added protection to the sealing surfaces and longer life, because the plug is firmly seated in the body in either open, closed, or throttle positions. And Homestead's straight line flow of fluid minimizes pressure drop. For extra long valve life on corrosive or erosive services where a non-lubricated valve is preferred, specify Homestead Lever-Seald Plug Valves. Mail coupon for more information.

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HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving Since 1892"
P.O. Box 160, Coraopolis, Pennsylvania

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Please send Reference Book 39-3 and prices on all types of Homestead Lever-Seald Valves.

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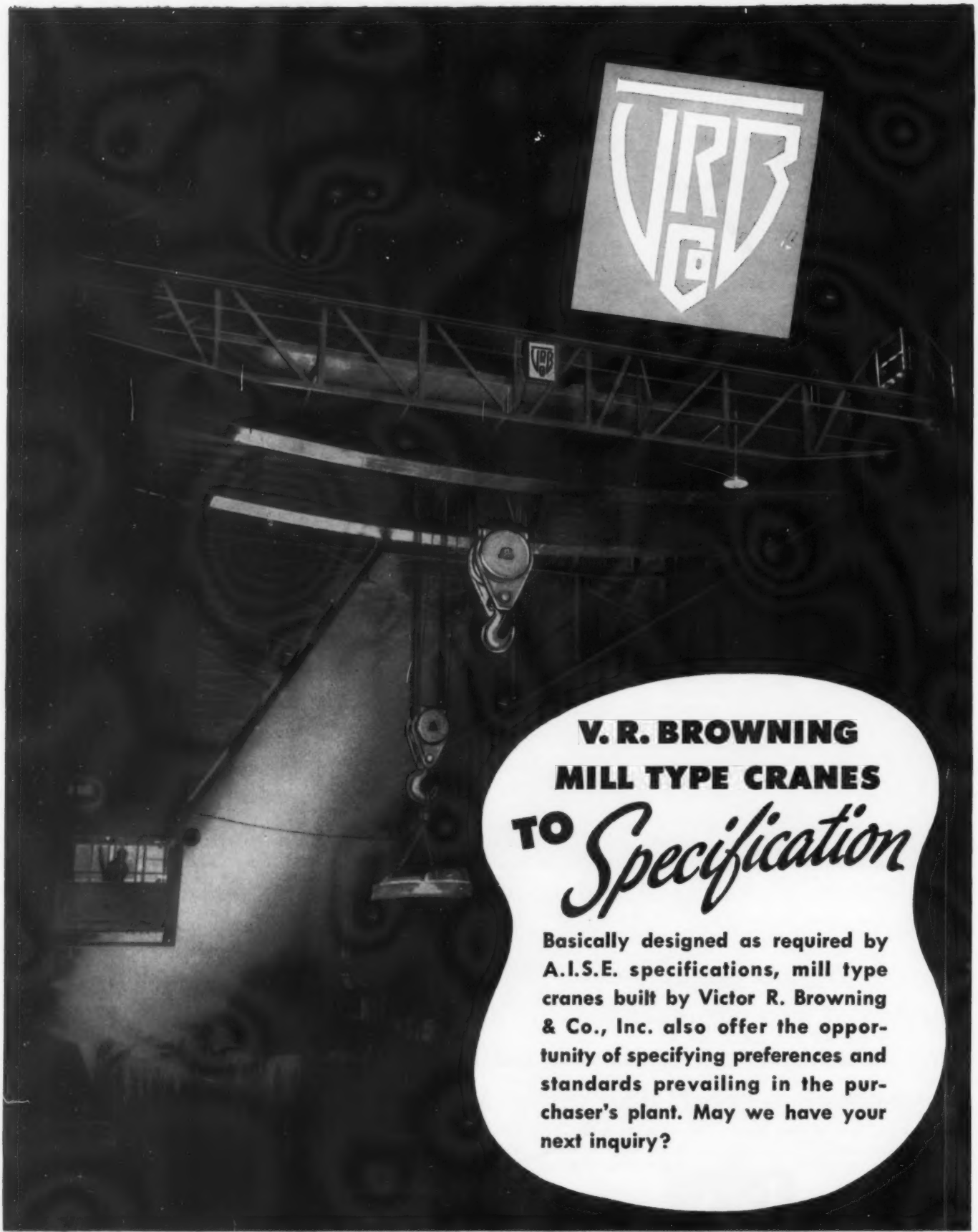
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BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

NEW

ONE PIECE BLOW PIPE (and seat)

HIGHER SAFETY FACTOR

INCREASES EFFICIENCY

ELIMINATES COSTLY BREAKDOWNS

One of the latest developments in blast furnace components . . . A ONE PIECE CENTRIFUGALLY CAST HEAT RESISTING ALLOY BLOW PIPE AND SEAT. Formerly cast in three sections and welded; the new one piece Cleveland Alloy Method decreases costly break-downs due to weld burn-outs. Designed to withstand increased temperatures. Refractory insulation liner optional. Cleveland Alloy Blow Pipes and Seats can be produced in a range of analysis including columbium and nitrogen stabilized alloys.

Cleveland Alloy Castings, Inc.

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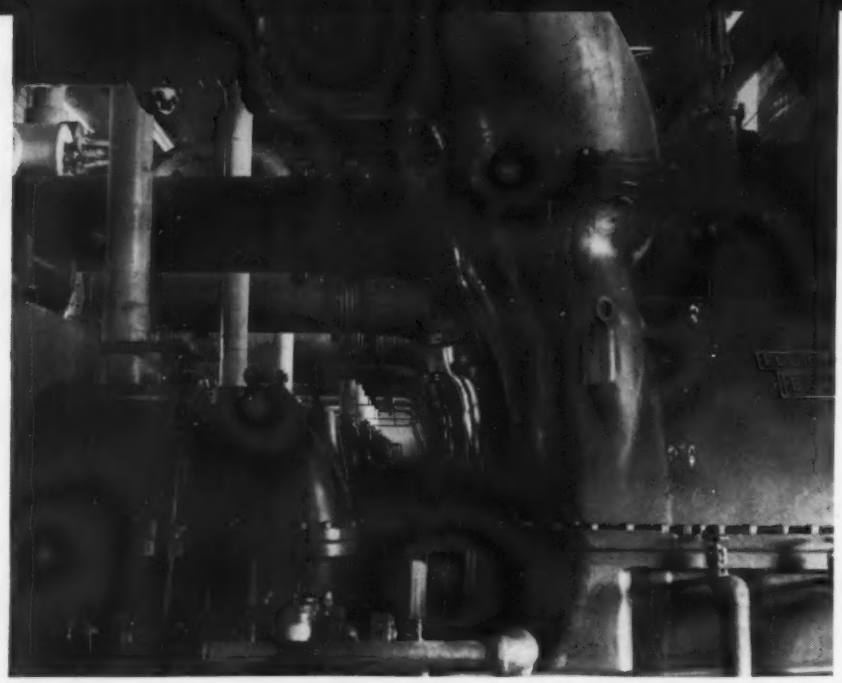


At Weirton Steel Company, eight Elliott compressors (photo right) serve a battery of 253 coke ovens. Four are exhausters rated at 24,500 inlet cfm, and four are boosters rated at 25,000 inlet cfm. All are driven by Elliott turbines.

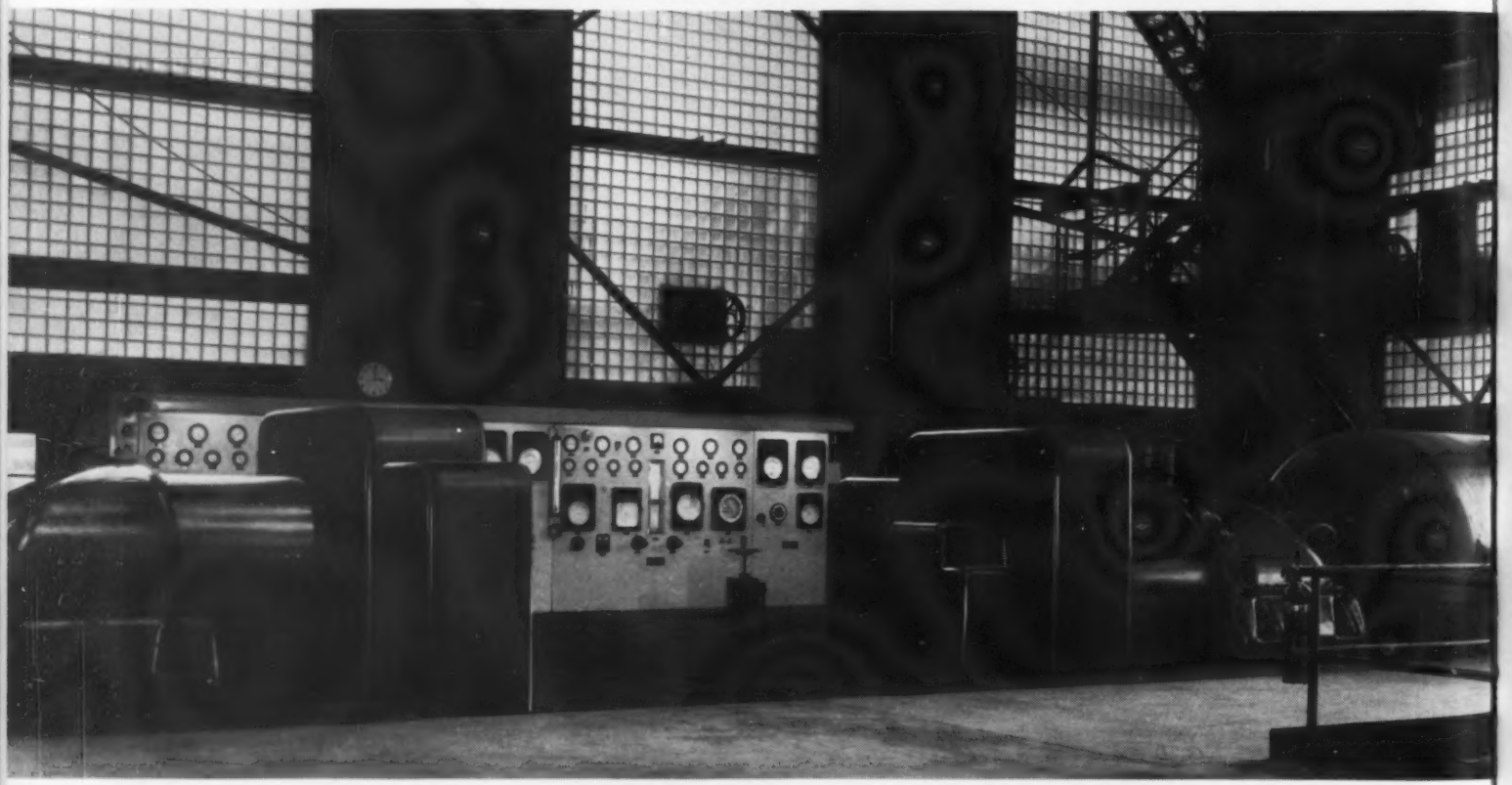
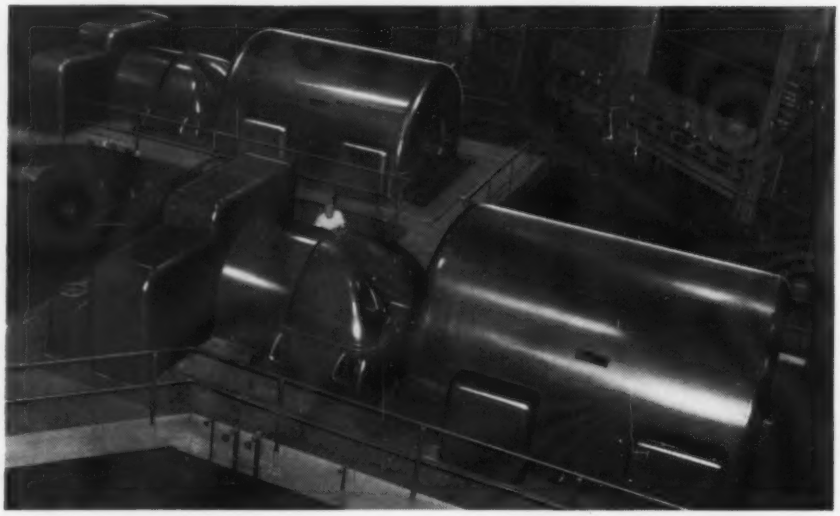


Photo above shows duplicate Elliott blast furnace compressors. Each is rated at 99,600 inlet cfm, and is driven by an 11,800-hp Elliott turbine.

At the right are shown two of three Elliott centrifugal air compressors operating in a single blast furnace plant. All three units—driven by Elliott turbines—are rated 90,000 scfm at 30 psig air discharge.



Engineered and built for Blast Furnace and Coke Oven Service . . .

ELLIOTT CENTRIFUGAL AND AXIAL COMPRESSORS

Extensive experience in the design and application of centrifugal compressors is reflected in the excellent performance of Elliott machines for blast furnace and coke oven service. Since 1926, Elliott has made industrial compressors, and many of these are furnishing air for blast furnaces, and serving as boosters and exhausters for coke ovens. Typical examples are illustrated on these pages.

COORDINATED ELLIOTT DRIVERS

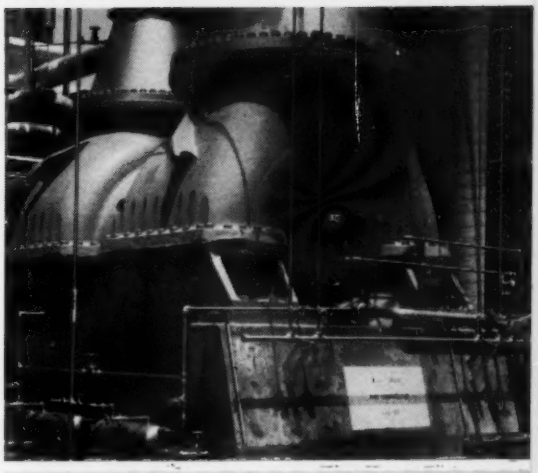
Elliott is a leading manufacturer of both steam turbines and electric motors, of all types and ratings necessary to provide driving power for compressor units. Consequently, we are in position to recommend and furnish the type of drive best suited for each application. Both units being engineered and built by Elliott is a decided "plus" because it means unified responsibility, unified service.

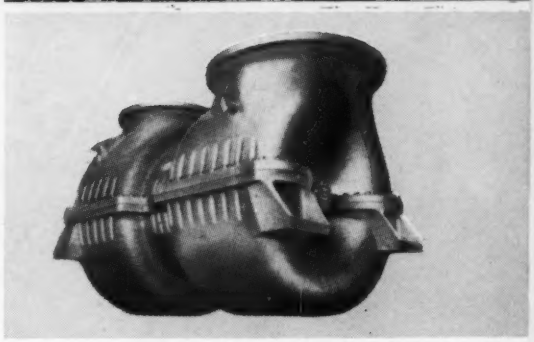
FOR AIR OR GASES

Elliott integrated compressor units are available for handling all types of compressible fluids, within the pressure and flow limits of the machines. Where corrosive gases are handled, special materials are employed in vulnerable spots; where high pressures are needed, extra heavy construction is used; where leakage must be prevented, special shaft seals are available; where high temperatures must be avoided, provision is made for cooling.

48 STANDARD FRAME SIZES

A total of 48 frame sizes permits accurate compressor application over the entire range of 500 cfm to 600,000 cfm. Pressures and speeds can be selected to meet the characteristics of the application, and the gas to be handled. For further information, write Compressor Department, Jeannette, Pa.





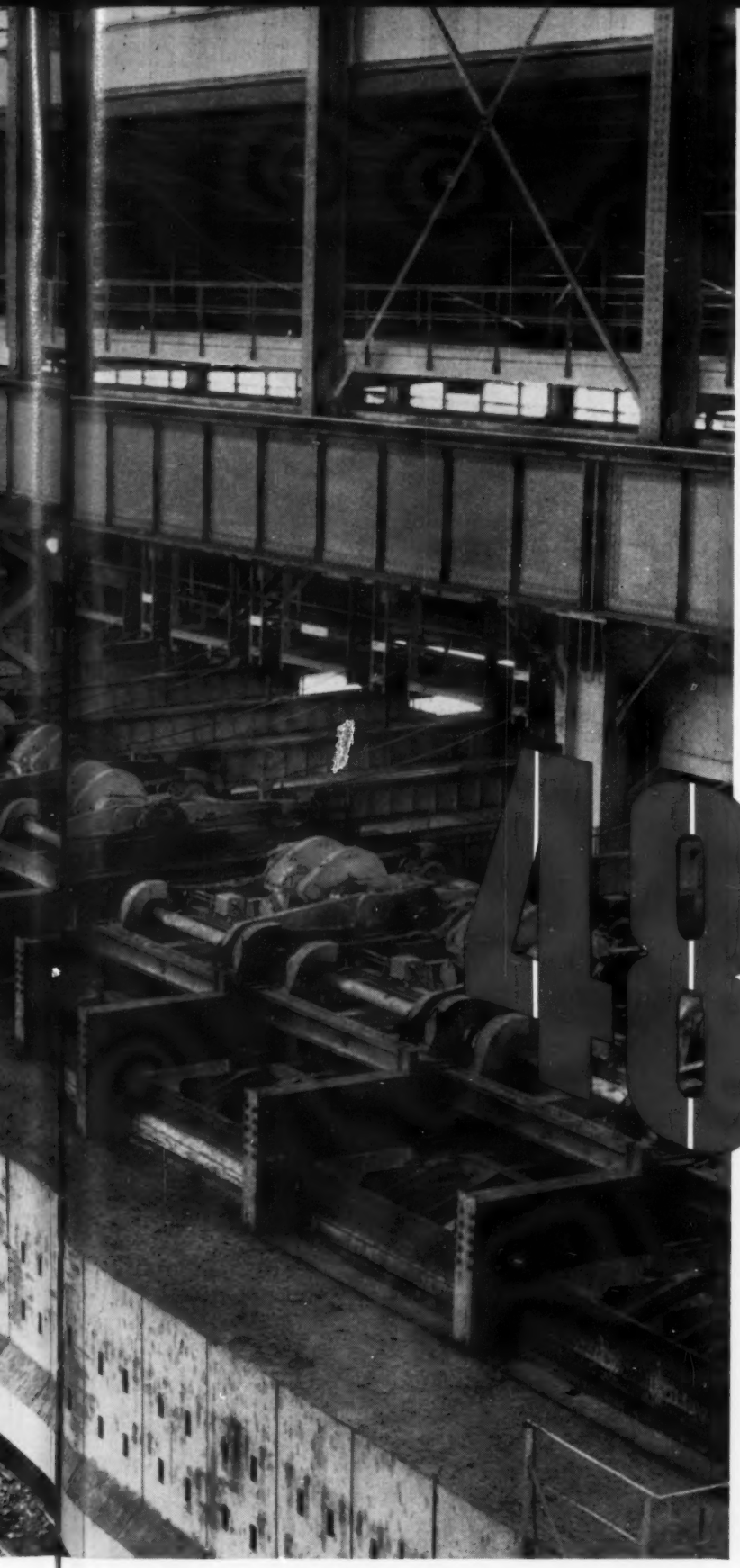
Multi-stage compressors of the axial flow type are designed and engineered specifically to serve the needs of the iron and steel industry for the handling of air or gas mixtures in large volume flow operation. Frame sizes are rated up to approximately 600,000 cubic feet per minute when operating on air.

ELLIOTT THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

ELLIOTT Company
Jeannette, Penna.

This is the largest installation of soaking pits ever built at one time. It will heat an average of 750 tons of ingots per hour. At peak capacity, it will fill the ingot buggies at a rate of 1200 tons per hour.

Worldwide engineering and manufacturing facilities through associates in Australia • Belgium • France • Germany • Great Britain • Italy • Japan



■ Forty-eight soaking pits on *one order*. There's a bold act of customer confidence for you! Confidence in the future, for one thing. Confidence in the principle of the Surface one-way fired soaking pit with the jet pump recuperator system. Many other steelmakers have shown similar faith in Surface—a source of pride, matched by our determination to deserve it, ***wherever heat is used in industry***

48 PITS

SURFACE COMBUSTION

2404 Dorr Street, Toledo 1, Ohio

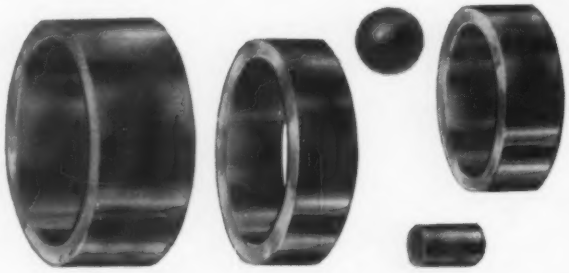
A Division of Midland-Ross Corporation

Surface

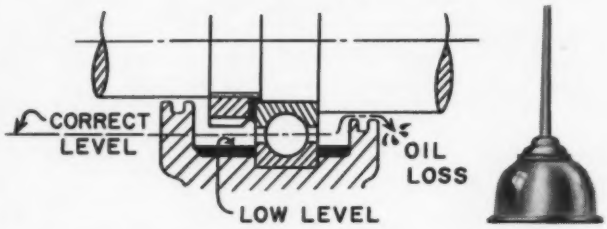
DISTRIBUTOR DAN, the SKF bearing man, tells

WHY BEARINGS BECOME OVERHEATED

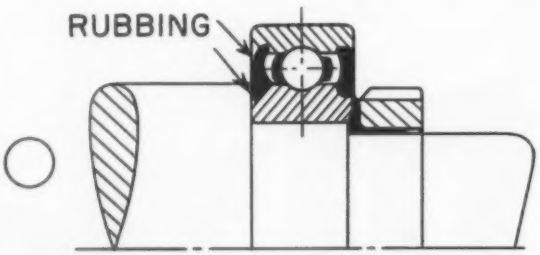
and how to correct the conditions that cause excessive heat.



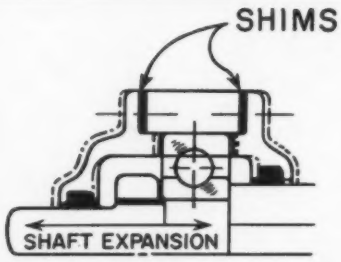
LOOK FOR THIS SYMPTOM. Discoloration of a bearing's rings, balls or rollers is a sure sign of overheating. The color is usually a gun-metal blue or bluish black.



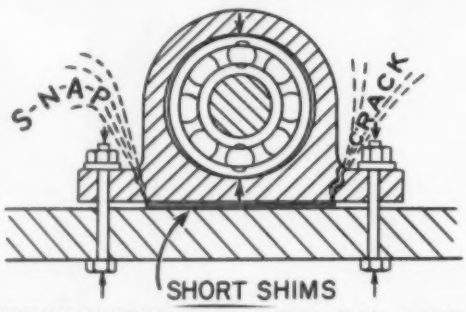
IMPROPER LUBRICATION OR LUBRICANT accounts for most cases of overheating. In pillow blocks, if oil is specified, fill only to the center of the lowest ball or roller in the bearing. If it's grease, the lower half of the pillow block should be filled. Therefore, be sure you're using the right lubricant—**in the proper quantity.**



RUBBING is a frequent culprit. Check the running clearance of the bearing seal. If it rubs against the shaft shoulder, re-machine the shoulder, to allow proper clearance. Bent lock-washer prongs are sometimes to blame. Straighten them or replace the washer.



EXTERNAL HEAT, conducted through the shaft, can make an inner ring expand excessively. It's usually the result of using a bearing with inadequate internal clearance. Make sure the replacement bearing is exactly the same as the original bearing. Should the markings be indistinct, consult an **Authorized SKF Distributor.**



THE BEARING HOUSING may be to blame—if it's warped or if the bore is distorted and out-of-round. Check to see whether the bore is pinching the bearing and relieve by scraping the bore. Make sure, too, that the pedestal surface is flat and that any shims cover the entire base area.

Baffled by a bearing problem? Whether it's selection, mounting, or maintenance—consult your Authorized SKF Distributor. He's staffed to help you keep them running smoothly and he stocks all the bearing types and sizes you need.

Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

® REG. U. S. PAT. OFF.

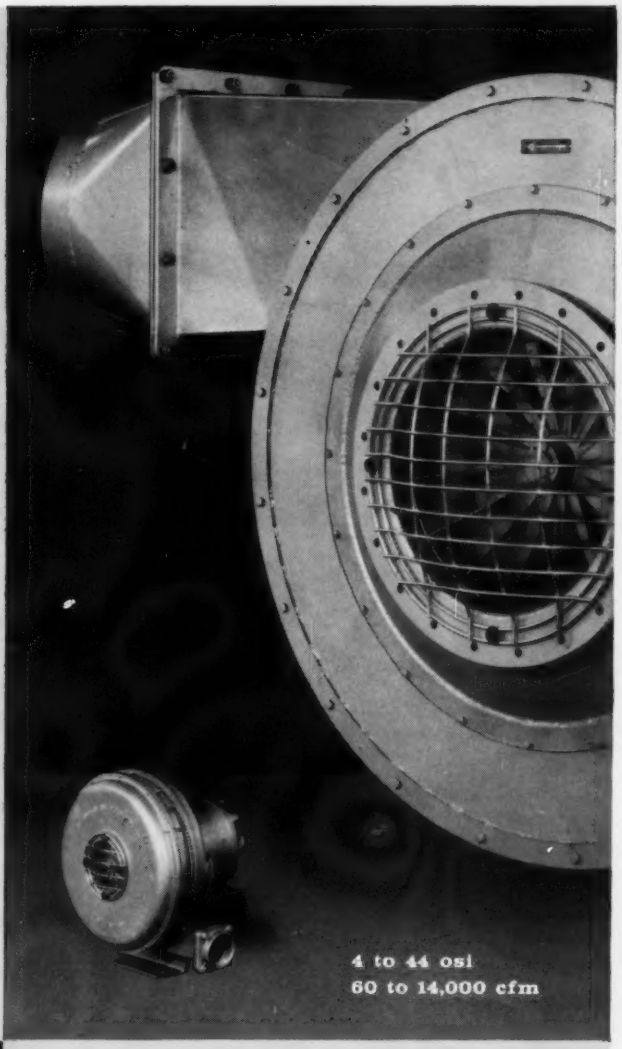
North American TURBO BLOWERS

High $\frac{cfm}{hp}$ Ratio

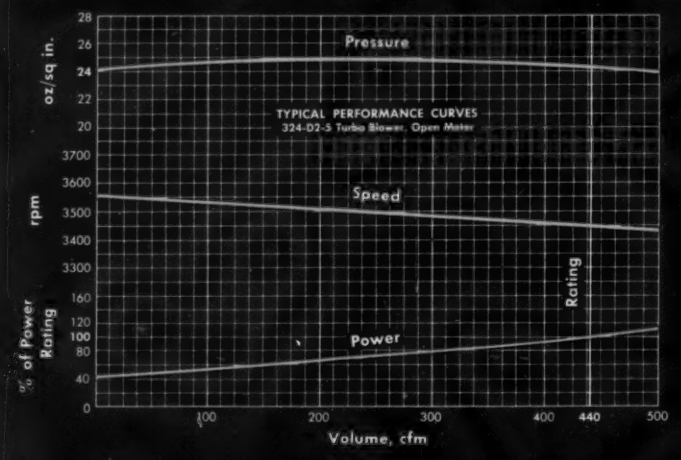
Accurately Rated & Tested

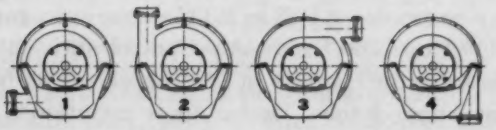
Continuous Industrial Service

Many Options



maintain constant pressure within rated volume—
for combustion
atomizing
agitating
blowing
cooling
drying
conveying
exhausting





Call your nearby North American engineer
or write for bulletin 300

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

The North American Mfg. Co.
Cleveland 5, Ohio

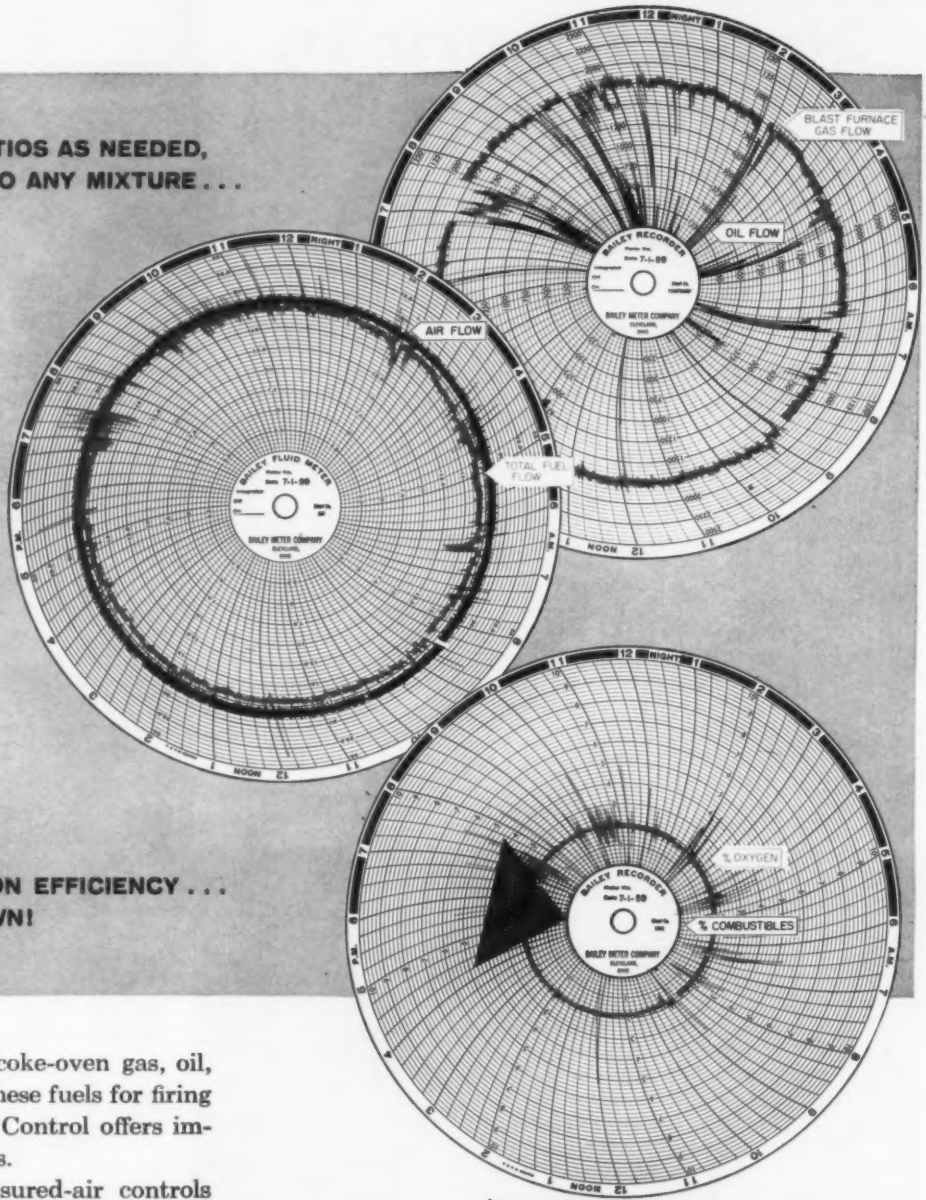
If you burn MULTIPLE FUELS...

Bailey Constant Excess-Air Control will . . .

1 **CHANGE FUEL-MIX RATIOS AS NEEDED, FROM DEAD SHUTOFF TO ANY MIXTURE . . .**

2 **ADJUST AIR FLOW TO CHARACTERISTICS OF FUEL MIXTURE . . .**

3 **OPTIMIZE COMBUSTION EFFICIENCY . . . BRING FUEL COSTS DOWN!**



▶ 0% combustibles—24 hours

If you are using blast-furnace gas, coke-oven gas, oil, natural gas, or any combination of these fuels for firing boilers, Bailey Constant Excess-Air Control offers important—and demonstrated—savings.

Ordinary measured-fuel and measured-air controls alone cannot maintain optimum efficiency with multiple fuels, because the heating value of each fuel varies. Blast-furnace gas varies ±10% in BTU—coke oven gas ±5%.

Bailey Constant Excess-Air Control anticipates and compensates for changes in heating values as fuels, or fuel mixtures, change. Excess air is maintained within constant limits for all fuels—combustibles are held at zero despite extreme changes in fuel flow. Note, in records above from a large eastern steel mill, how oil is brought on, when needed, from a full shutoff (Chart 1). Fuel-air ratio is adjusted (Chart 2) to maintain constant excess air in spite of changes in fuel-flow rates, mixture ratios, heating values and air temperatures. Chart 3 shows variations in oxygen content occuring with changes in fuels, which have been controlled to produce an almost complete absence of combustibles—and a net 5% saving in total fuel costs!

You can apply this to your existing boilers. Ask for full facts and figures from your Bailey engineer.

S118-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

A Rex Coil Conveyor System in a large steel producing plant.

why REX® coil conveyor chain keeps DOWN TIME down

Years of dependable service in many rugged mill applications is proof that Rex Coil Conveyor Chain is a top runner in slashing down time and maintenance costs.

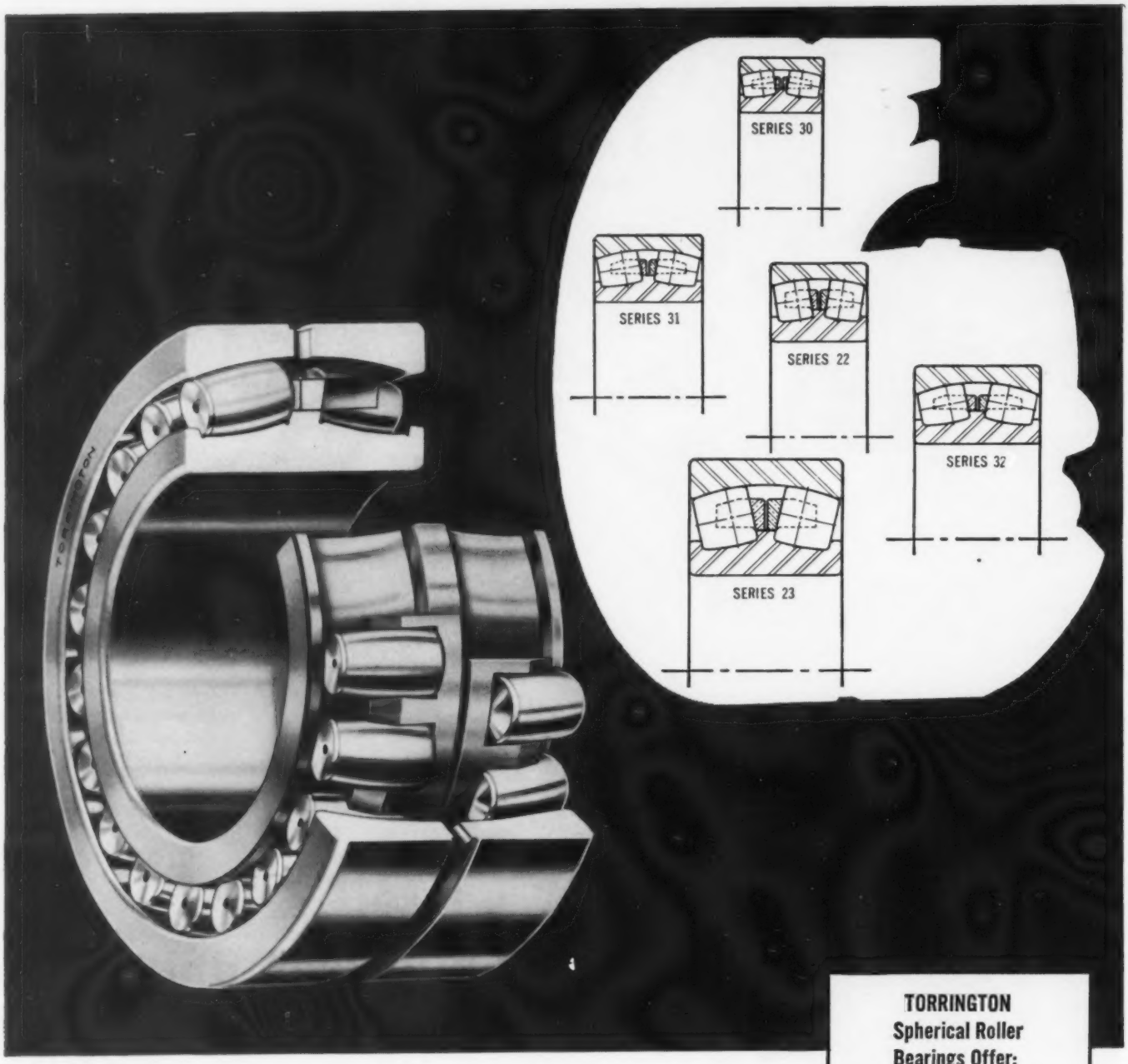
Reason is this: Rex engineers were not satisfied with a "me too" chain. They turned to basic research to give this chain the ability to take it. They selected the materials and the design that would assure the most efficient combination of strength, wear life and economy—used heavy-duty antifriction roller chain to supply smooth operation—attached rugged platforms for a steady, level carrying surface. And over 70 years of CHAIN Belt manufacturing experience, plus rigid quality control, makes sure Rex Chains perform as planned.

Write CHAIN Belt Company, 4693 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto.

REX®

CHAIN BELT COMPANY

REX IS BEST . . . IN THE USER TEST



There's a Torrington Spherical Roller Bearing for your application

Bearings matched *exactly* to the job pay off in better performance, longer life, greater reliability. That's why it pays to specify carefully. And that's why it pays to choose Torrington Spherical Roller Bearings.

Whatever your space limitations or capacity requirements, the five series of Torrington Spherical Roller Bearings provide the right bearing for virtually every industrial application. You can design for straight bore or tapered bore with adapter. You can benefit from extra features such as lubrication groove and oil holes, or selected outside diameters.

Your use of Torrington Spherical Roller Bearings will assure exceptional operation and longer bearing life under the toughest conditions. They're made to Torrington's own uncompromising standards—the highest in the field of anti-friction engineering—by the manufacturer of every basic type of anti-friction bearing.

TORRINGTON Spherical Roller Bearings Offer:

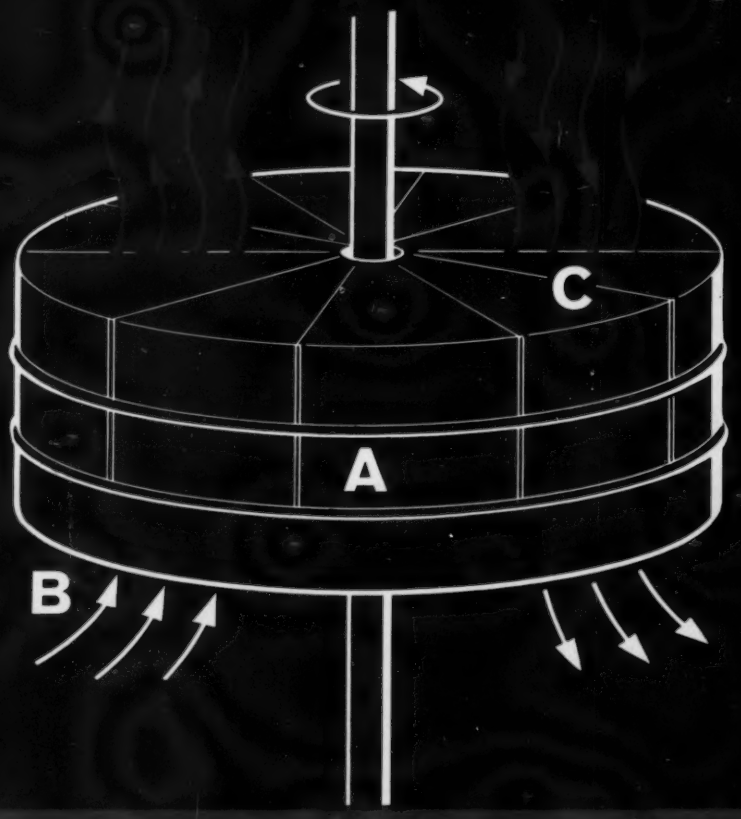
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- inherent self-alignment
- even load distribution
- long, dependable service life

Send for new Torrington Spherical Roller Bearing Catalog #258

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

COMPACT ROTARY HEAT EXCHANGER NOW AVAILABLE FOR STEEL INDUSTRY



Rotary regeneration makes the Ljungstrom more efficient than any other heat exchanger because the heat is absorbed by, and released from, **the same metal surface.** Heat recovery is continuous and uniform. All the heat exchange elements are contained in the rotor (A). Exhaust gases (B), diluted with air if necessary, pass through half the rotor and heat the elements. As the rotor revolves, these heated elements pass through the counterflow incoming air at (C). The incoming air absorbs the heat and carries it back to the combustion chamber. The Ljungstrom can be adapted to either horizontal or vertical flows of gas.

Example: Can preheat air from 70° F to 1380° F

The Ljungstrom® Air Preheater is the most efficient metallic heat exchanger ever developed. It's the only heat exchanger *of any type* that, with an exhaust temperature of 1500°F, can raise incoming air from 70°F to 1380°F—and do it in so little space. A Ljungstrom measuring about 5′ x 7′ x 8′ can handle a furnace exhausting 30 x 10^6 Btu/hr.

It's the continuous rotary regenerative principle that makes the Ljungstrom so efficient and so compact. Essentially, this rotary principle (explained more fully in the diagram above) permits the accumulation and release of heat by the same surface, thus reducing the surface required to recover a given amount of heat.

Another Ljungstrom characteristic is absolutely uniform air preheating. The slowly revolving Ljungstrom rotor heats incoming air continuously, so you get a *steady high temperature* instead of fluctuations typical of cycling checkers. And because of the depth of the heating elements—two to three feet—the heating surfaces can be readily cleaned to maintain continuous maximum recovery.

Ljungstroms have been used with many types of fuel, including crude and refinery oils, coke-oven gas, natural gas and blast furnace gas. Applications include industrial and utility boilers, high temperature refinery stills, and special industrial processes of many types.

Present high-temperature designs accommodate exhaust gases to 1500°F, and Air Preheater is developing and testing designs for temperatures well above 2000°F. The Ljungstrom Air Preheater has many potential steel mill applications: soaking pits, slab, billet and skelp heating furnaces, etc. For further information on the Ljungstrom Air Preheater and its possibilities for heat recovery in steel mills, phone or write to:

THE AIR PREHEATER CORPORATION

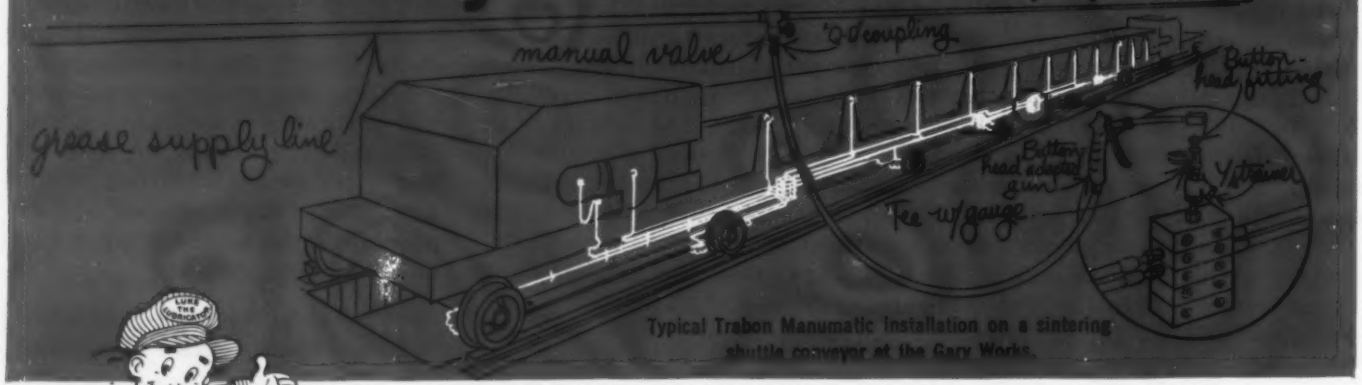
60 East 42nd Street, New York 17, N. Y.
MUrray Hill 2-8250

TRABON®
CENTRALIZED LUBRICATING SYSTEMS

Trabon Manumatic Systems were selected by U.S. Steel to provide the simplest, most positive means of lubricating a large number of bearings at their new Gary Sintering Plant. Nine automatic air-operated pumps supply grease under pressure to header lines, lubricating idler rolls, return idlers, take-ups, etc. To lubricate 50 or more bearings at any Manumatic station, the operator simply opens the valve for five or ten seconds. There are no hand pumps to work or fill—no tedious checking of individual valve indicators. And every Manumatic System has built-in central warning! Specify Trabon, the modern way to protect your machinery.

21,591 bearings at the new Gary Sintering plant...

lubricated by Trabon - and not a hand pump to fill or work



Typical Trabon Manumatic installation on a sintering shuttle conveyor at the Gary Works.

"Centralized" OIL AND GREASE SYSTEMS "Meterflo" CIRCULATING OIL SYSTEMS
"Meter-Mist" OIL SYSTEMS

Trabon® Trabon Engineering Corporation 28785 Aurora Road • Solon, Ohio

Equipment News...

FLOODED DISK SCRUBBER

△ A new type of scrubber employing a unique adjustable flooded disk has been developed by Research-Cottrell, Inc. for high efficiency gas fume cleaning.

Major feature of the unusual new scrubber is its ability to adjust for maximum cleaning efficiency over a complete range of operating conditions. At gas flows 50 per cent higher or lower than normal, water rates and pressure drop remain the same while gas cleaning efficiency is maintained at a high level.

By recirculating dirty water without impairing efficiency, the flooded disk scrubber also makes it possible to use smaller and more economical effluent treatment systems. Low-pressure plant water cannot clog large-area water passages used throughout this compact and rugged scrubber.

Completely automatic operation of the scrubber has also been developed by Research-Cottrell engineers to provide continuous automatic adjustment over an entire range of plant operating conditions. Design of the new system adapts itself to wide plant variation rather than a specific set of rated conditions.

Designed for modern high gas pressures, the basic principle of the flooded disk scrubber is a turbulent flow of a gas-liquid mixture that provides an intimate and violent contact between dust and liquid particles. Water or other scrubbing liquid enters through the stem of the disk support and is injected into the gas duct at the center of the disk. The water is deflected to the rim of the disk where it mixes with incoming gas in the annular space between duct and disk. Here the water breaks up into millions of extremely fine particles which collide with and adhere to the dustfume.

Repeated collisions of the fume-water mixture agglomerate and enlarge the particles. These particles quickly become large enough for separation and collection in a cyclonic mist eliminator which follows the scrubber.

Pressure drop through the flooded disk scrubber can be kept constant at all gas flows from 50 to 150 per cent of rated conditions. Consequently, gas cleaning efficiency will remain the same at all flow conditions. At high gas flows blowing system equipment is not burdened with an extra power load at the wrong time. During a 20-minute cycle for an oxygen converter, for example, where gas flow changes over a wide range, the flooded-disk scrubber can maintain constant pressure drop through the whole cycle. Water rates can be increased, not decreased, to take care of increased gas flow.

Large water passages in the new scrubber make it possible to operate effectively with very dirty water. With no restrictions or nozzles to plug up, maintenance and replacement downtime are negligible on the flooded disk system. Water can be constantly recirculated through the system and the effluent volume reduced sharply. This makes it possible to reduce the size and cost of effluent treatment equipment.

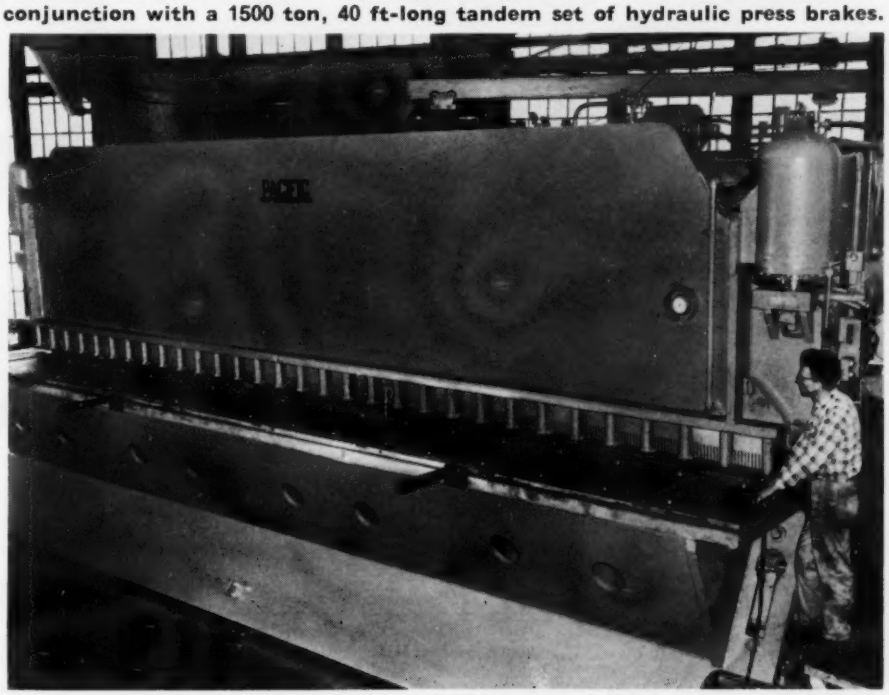
The flooded disk design eliminates long converging and diverging flues. Compact and easy to operate, the new scrubber takes up a minimum of plant space. Areas subject to natural abrasion are limited to the disk and cone, and only small amounts of abrasion-resistant materials are needed. With automatic adjustment controls the flooded disk yields continuous optimum performance without the attention of plant personnel.

ROLLER STRAIGHTENER

△ Two new overhung roller straighteners, engineered and built by

FIRM UNVEILS GIANT PLATE SHEAR

This mammoth hydraulic plate shear, capable of shearing ½-in. steel plates over 30 ft long in a single stroke, is readied for shipment to Daniels Standards, Nashville, Tenn., for fabrication of tapered tube light poles. Manufactured by Pacific Industrial Manufacturing Co., this adjustable rake shear will be used in conjunction with a 1500 ton, 40 ft-long tandem set of hydraulic press brakes.



WHIRLEX fans and dust collection equipment offer the maximum in efficiency regardless of the size or operating conditions. A wide variety of designs, metals and linings are available to you from WHIRLEX!

FLY ASH ARRESTOR
CORPORATION
205 North 1st Street / Birmingham, Alabama
1355 Market Street, San Francisco 3, Calif.
420 Lexington Avenue, New York 17, N.Y.

Bag Collectors ■ Mechanical Collectors ■ Wet Collectors
Induced Draft Fans ■ Forced Draft Fans ■ Exhaust Fans
Self Supporting Stacks ■ Duct Work

Birdsboro Corp., have been installed at the South Chicago Works of United States Steel Corp.

The machines are capable of straightening wide flange beams up to 16 in. wide, standard beams up to 15 in. wide, channels up to 18 in., and equal and unequal angles up to 8 in. x 8 in. x 1⅛ in. The straighteners are designed also to handle sheet piling and other special shapes.

Both units are nine-roll machines. Each straightener has five vertically adjustable top rolls, and four nonadjustable bottom rolls. All nine rolls are adjustable axially.

On each machine, all rolls are driven from an external drive pinion stand through gear type spindle couplings. In addition, slip clutches are mounted in the bottom roll spindles to accommodate variations between top and bottom roll diameters. Vertical and axial roll adjustments are electrically motor powered. The main variable speed d-c motor enables the equipment to straighten structural shapes at speeds ranging from 300 to 750 fpm.

Vertical pinch rolls on the entry side and vertical pressure rolls on the delivery side feed and guide materials to be straightened. The pressure rolls also aid in decambering.

Each horizontal work roll is mounted on a sleeve having a tapered bore which seats on the end of an overhung spindle. The sleeves are placed in position by means of a hydraulic jacking system built into the retaining nut. They are removed by pumping oil, under high pressure, between the sleeve bore and the spindle. All the sleeve bore and spindle end tapers are matched so that any sleeve may be mounted on any spindle.

A bayonet retainer is placed between the retaining nut and the sleeves to facilitate removal of the sleeves. Backing the nut off just a fraction of one turn permits 120 deg rotation of the bayonet retainer. This amount of rotation in turn, frees the roll sleeve for removal.

When the equipment straightens beams and channels, each roll is built up using two roll rings and a series of split spacers. When other sections are handled, a solid preshaped roll is used.

CUT GRINDING TIME...IMPROVE FINISH

WITH MIDVAC

Micro Lustre

VACUUM MELTED FINISHING ROLLS

Made from consumable electrode vacuum melted Midvac Steels these rolls offer qualities unsurpassed in cleanliness and ductility by any metal finishing rolls. They have a super uniformity of fine grain structure, maximum freedom from defects and non-metallic inclusions.

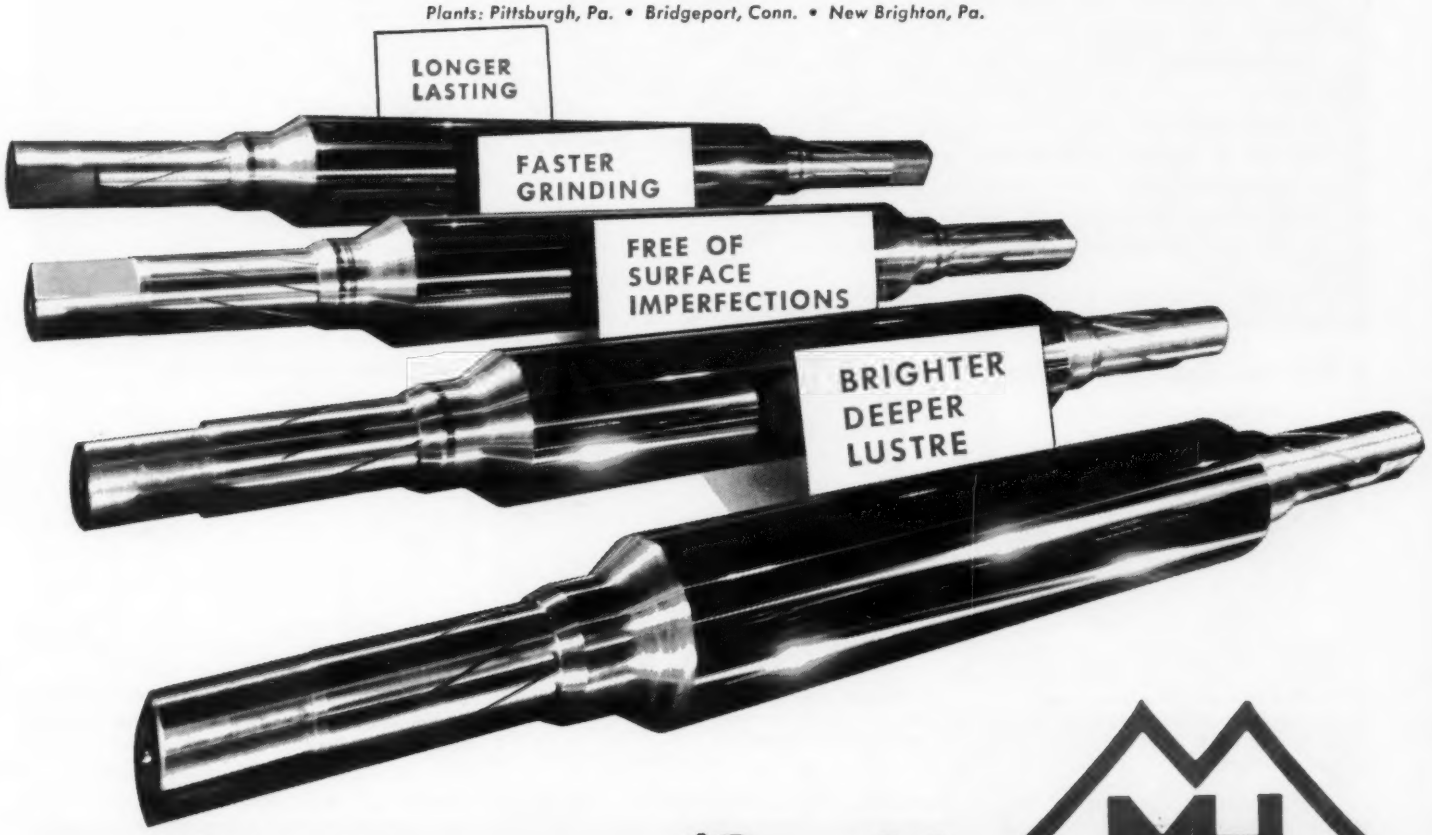
Midvac Rolls are precision ground to a deep, black, Micro-Lustre finish... assure rolling of stainless steel, foil and precious metals free of surface imperfections. The super uniformity throughout has resulted in rolls lasting twice as long between grinds. The deep Micro-Lustre grain structure makes it possible to cut grinding time in half.

Improve product quality and get more footage out of every roll — specify Midvac Rolls on your mills. Midvale-Heppenstall also makes forged rolls for rolling steel and non-ferrous metals, paper, plastics and rubber.

MIDVALE-HEPPENSTALL COMPANY • NICETOWN, PHILADELPHIA, PA.

SUBSIDIARY OF HEPPENSTALL COMPANY, PITTSBURGH, PA

Plants: Pittsburgh, Pa. • Bridgeport, Conn. • New Brighton, Pa.



Midvac Rolls

MH

MORE MILLIONS OF OPERATIONS

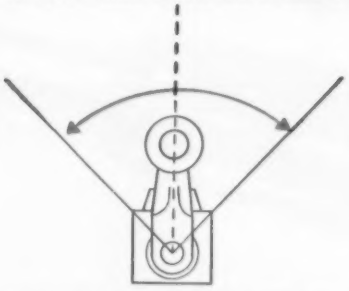
with Allen-Bradley Limit Switches

There's nothing now on the market to match the reliability and trouble free performance of Allen-Bradley Bulletin 802T limit switches. They are completely oiltight—operating heads and switch bodies are sealed against oils, coolants, and metal chips. Operators cannot become sluggish or "stick" in operation—contacts cannot become fouled. The double break, silver contacts are always in perfect operating condition—and remain so without maintenance.

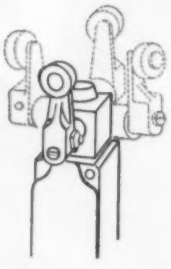
Insist on Allen-Bradley—the *quality* line of limit switches that will give you *many more millions* of trouble free operations.

Bulletin 802T Micrometer Adjustment Roller Lever Limit Switch ▲

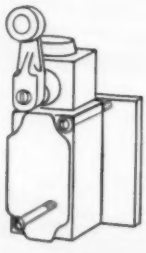
A-B Limit Switch features mean more life, more dependable trouble free service

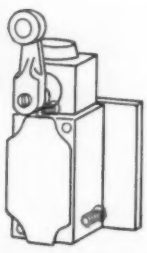


REPETITIVE ACCURACY—Unique toggle blade action assures operation at precisely the same point each time, without adjustment.



FLEXIBILITY—All operating heads can be rotated and fastened in any of four positions 90° apart.





FRONT MOUNTING **REAR MOUNTING**

All Allen-Bradley Limit Switches can be mounted either from the front . . . or from the rear.

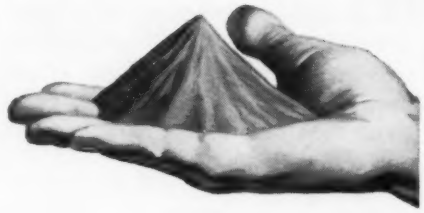
Allen-Bradley Co., 1343 S. First St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Lt., Galt, Ont.

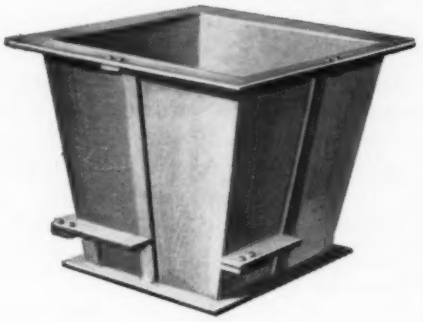
ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

For accurate reproduction of bulk material formulations—W-C BATCH-WEIGHING SYSTEMS





In any batching operation—from simple dump-and-fill weighing to multi-ingredient ratioing — W-C Batch-Weighing Systems provide the reliably accurate net-weight control essential to consistent product uniformity.

Chief reason for this is the W-C Pneumatic Weight Transmitter. A rugged yet sensitive force-balance unit, it is capable of an accuracy of ±0.25% calibrated weight range, with reproducibility better than 1 part in 2000.

Each W-C Batch-Weighing System is designed to job specifications, using pre-engineered, unitized components of *known* performance capabilities. Consequently, you are spared the uncertainties—and costs—of "prototype" engineering . . . yet you realize the very tangible benefits of an application-engineered system built to your requirements.

Typical applications include: Batching bonding agents for foundry formulating molds . . . batch-weighing molten metal in ladle prior to pouring.

Write for new Bulletin 14

W & C **WEIGHING & CONTROLS, INC.**
Div. of CompuDyne Corp.

E. County Line Road • Hatboro 16, Pa.

SPEED REDUCERS

△ A new line of spiral bevel speed reducers designed to take up less floor space than other reducers has been developed by Hewitt-Robins Inc.

The new reducers have a right-angle shaft arrangement which makes it possible to place the prime mover alongside the driven equipment, resulting in important savings in floor space compared with parallel or concentric shaft reducers.

The spiral bevel gears are more efficient than worm gears used in right-angle drives. Thus in many applications the use of bevel gear drives makes it possible to reduce the size of the motor, controls and other accessories. The energy loss for a single reduction spiral bevel reducer is approximately two per cent. For a double reduction it is three per cent, and for a triple reduction four per cent.

MOTOR INSULATION

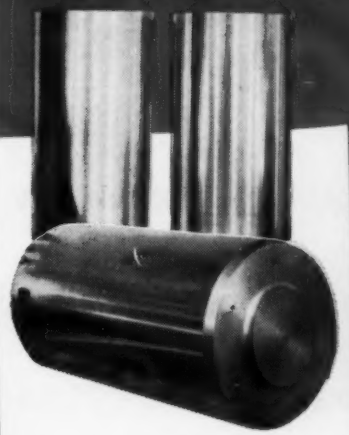
△ A new epoxy insulation system for electric motor coils has been announced by the Crocker-Wheeler Division of the Elliott Co. Known as Epa-Seal, the new system is applied to both random-wound and form-wound motors of 1 to 500 hp. This is believed to be the first time that this epoxy insulation has been offered in motors of the higher horsepower ratings.

For form-wound motors, the epoxy resin is applied to core and

frame before winding. Slot cells are epoxy-glass, and coils are covered with glass tape, with slot sections protected by epoxy-mica wrapper. After all coils are installed, the entire wound stator undergoes a vacuum-pressure process, which impregnates the coils, eliminates internal voids, and applies the epoxy resin to all external surfaces. Addi-

RED CIRCLE Rolls ALLOY-CHILLED

Hyde Park RAMS



for all types of HYDRAULIC EQUIPMENT

Hyde Park Rams are available in Chilled or Alloy Iron.

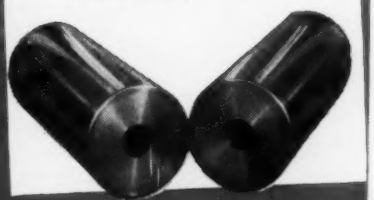
Furnished in hardness range to meet your specification . . . ground to your required size.

On your next replacement of Rams—or for new equipment—consult us. Our engineers will be glad to assist you.

Red Circle Rolls for every Purpose

Rolling Mill Equipment

Gray Iron Castings up to 80,000 lb.



Hyde Park
FOUNDRY and MACHINE CO.
HYDE PARK
Westmoreland County, Pa.

Rolls
Rolling Mill Equipment
Gray Iron Castings

tional protection is given coils where leads enter.

For random-wound motors, the entire wound stator is encapsulated by a vacuum-pressure system that drives the epoxy resin deep into the coil slots, filling them completely. There are no voids, and the tough, resilient, impervious material encloses coils in a homogeneous protective epoxy resin.

To test the effectiveness of the insulation, Elliott completely submerged an entire form-wound stator in water for three months. Subsequent tests showed that a high level of insulation resistance and dielectric strength were maintained. Likewise, a random-wound Elliott Crocker-Wheeler motor with Epa-Seal insulation was run while completely submerged in water for 1000 hr, without failure.

SURFACE GRINDER

△ The job of grinding special forms for twister guides used in the rolling of steel rod is simplified by a Landis Tool Co. Hydrabrasive 1224 precision surface grinder equipped with special tooling.

The workpiece is clamped in a special cradle attachment. A follower imparts a rocking motion to the cradle and workpiece to grind a predetermined radius, thus forming the twister guide groove. The cradle unit is adjustable for the amount of twist required in the various types and sizes of guides.

An adjustable radial dresser, installed on the cradle, is used to dress the necessary profile on the grinding wheel.

This special tooling may be removed and the machine used as a standard surface grinder with a worktable capacity of 12 in. x 24 in. and integral 3 hp motor and spindle.

To insure top performance in precision grinding jobs, the spindle has anti-friction, precision selected bearings.

For highly accurate transverse saddle adjustment, the unit is designed with precision ground crossfeed screw with backlash eliminator and ball bearing saddle ways. A hydraulic motor turns the screw for rapid saddle transverse when dressing the wheel.

The hydraulic controls on this machine are grouped for natural, effortless operation. They are mechanically interlocked for positive safety. A table hand feed wheel and crossfeed handwheel are standard on this power operated grinder.

The low pressure hydraulic system (225 lb operating pressure) is compact, easily removed for inspection or maintenance. The entire hydraulic unit may be rolled out in front of the machine on rubber mounted casters.

The unit is cooled by a large volume air flow over the system and up the column, aided by a TEFC motor. Because it is a low-pressure, high-volume system heat is not a problem.

A complete line of extra equipment and attachments are available for multiple wheel, wet grinding, crush forming and other special operations.

STOCKHOUSE CONTROL

△ The job of drawing iron ore, fluxes, and coke from hoppers, and weighing, mixing, and deposit-

FIELD TESTED, PROVED OVER 1 YEAR

PLIBRICO 80

80% ALUMINA PLASTIC

Offers ease of plastic installation... plus all advantages of high alumina content

Service temperatures to 3200° • Non-wetting to most metals • High abrasion resistance

Here are the proven facts about PLIBRICO "80" revealed by well over a year of actual on-the-job service:
PLIBRICO "80" provides a joint-free monolithic lining of high density . . . a lining that's non-wetting to aluminum, steel and brass . . . a lining that shows very good resistance to abrasion and excellent resistance to acid. Valuable features, all aimed at reduced maintenance costs. And what's more, PLIBRICO "80" is easy to work and install, requires no forms.

Here are just a few of its uses:
Aluminum remelt furnaces • Electric furnace roofs
Alloy steel, brass, and aluminum ladles • Burner cones

WRITE FOR LABORATORY REPORT PLR-910 giving technical data. Ask your Plibrico Sales Engineer about the multiple advantages of Plibrico "80".

REFRACTORIES ENGINEERING CONSTRUCTION
Plibrico

PLIBRICO CO., 1804 Kingsbury, Chicago 14, Illinois
Canadian Plant: New Toronto, Ontario
Sales & Service Throughout the World

0428

To Meet Customer Demands

New Side Trimming Line Installed In Tin Mill Will Improve Production Of Tinplate In Coils

Installation Called Most Modern Of Type In Industry

A new side trimming line to facilitate the production of tinplate in coils in Weirton Steel's Tin Mill Department was placed in operation recently.

W. H. Wright, Vice President and Chief Engineer, said the new installation, rated among the most modern pieces of equipment in the steel industry, was installed because of the increasing demand from customers for tinplate in coil form. The company will also continue to ship tinplate in the conventional cut sheets.

The new side trimming line, which began operating last month, and a second line, installed on an emergency basis, are used to trim the sides of the sheet steel before it is plated with tin, so it can be wound into coils and be ready for shipment as it comes off the tinning lines.

Mr. Wright explained that Weirton Steel's No. 4 and No. 5 tinplating lines have been equipped with edge control reels which insure that each coil is wrapped with a straight edge. This is necessary to prevent damage to the edges in bundling and shipping and also because straight edges are required when the coils are processed further by Weirton Steel customers.

Mr. Wright also reported the installation of a new bundling line, which began operating about three months before the new side trimmer. The bundling line utilizes machinery to wrap coils in heavy paper and fasten them with steel straps. Formerly, this was a hand operation.

The side trimming operation takes place after the steel has been tempered to customer specification by the skin mills and before it is plated with tin. This process eliminates the waste which formerly resulted when the side trimming was done on the cutting lines, after the tinplating process.

The No. 2 side trimming line has a maximum speed of 4,000 feet per minute while the No. 1 line operates at a speed of 1,200 feet per minute. The No. 2 line is able to handle 30-ton coils 85 inches in diameter and 45 inches wide. The line also is equipped with a mash welder, a relatively new operation which provides a smoother weld that does not damage other sections of the coil as it is wound.

All of the new facilities were designed by the Weirton Steel Engineering Department and installed by the company's Construction Department.

Reprinted from Employees Bulletin, Weirton Steel Company, February, 1960

Due to increasing demands from customers for tinplate in coil form, a new side trimming line was installed recently in the Tin Mill. The new trimming line, designed by Weirton Steel's Engineering Department and installed by the Construction D[illegible] the [illegible] of sheet steel bef[illegible]ted with ti[illegible]

Once again—

proof that GPE Controls is the Steel Industry's "Partner in Progress"

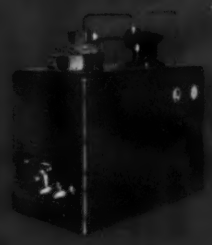
The tin mill side trimming line at Weirton Steel Company, Division of National Steel Corp., was furnished by Wean Engineering Co., and equipped with the industry's most modern edge guide equipment—designed and built by GPE Controls, Inc.

Only GPE Controls offers steel mill edge guides with . . .

★ Non-clogging sensing nozzles with lowest air consumption.

★ Unlimited force output with cylinder pressures to 2000 p.s.i., flows to 140 g.p.m. and higher.

★ Variable-gain booster for simple screwdriver job-site matching of control system to speed, coil weight, etc.



GPE Controls Model 300 Edge Control, as furnished to Weirton Steel Company.

Write for NEW Bulletin EG04, which tells all about GPE Controls web guiding systems—and be sure that GPE Controls are specified and furnished on your next strip and tin mill installation.

GPE Controls, Inc.
240 East Ontario Street
Chicago 11, Illinois

GPE Controls | A GENERAL PRECISION COMPANY

A subsidiary of General Precision Equipment Corporation

ing them in a blast furnace at the correct time will be automatically controlled at the U. S. Steel Corp.'s Gary Works with Prodac control designed by Westinghouse Electric Corp. In addition, the type and quantity of deposited material and the time at which it is charged will automatically be recorded on punched tape.

Because a wide variety of charging schedules are used in a blast furnace, a prime requirement of a programmed control is flexibility. To achieve this flexibility, the command information in this system is set up by an operator with patchboard leads and selector switches. With this scheme, the operator can quickly set up or change the program, which includes the sequence of skips, the material included in each skip, the quantity of material in any one skip, and the bin in which the material is stored. In this way, a new shipment of ore or flux can be stored in any one of the 14 bins. When the hopper has been filled, the operator merely connects, with a patchboard lead, the number of the bin and the material stored in it.

Ores and fluxes are stored in 14 hoppers; there are two main conveyors, each one serving seven hoppers. Material from each hopper is weighed on a weighing conveyor and then deposited on a main conveyor. A weight sensing device on each weighing conveyor produces a digital pulse for every 50-lb of material. Because of the design of the digital counting system, two hoppers can unload their material onto a main conveyor at the same time, reducing over-all operating time.

Once the operator has set up the program on the patchboard, the charging cycle is completely automatic.

For example, if one bin of a given material is empty, the control will automatically choose another bin of the same material as well as indicating the empty conditions of the first bin.

Further, if the chute of the bin becomes clogged, the control will initiate a vibrator. If the vibration does not restore the flow of material, the control will automatically sound an alarm, turn on an indicating light to show which bin is jammed, select another bin with the same material, and continue the programmed operation.

The automatic data accumulation part of the control records the weight of each material used and the time at which it is charged into the furnace. This allows a complete breakdown for accounting purposes, and comparison of the charging program with the quality of the finished product.

CRANE RAIL LUBRICATION

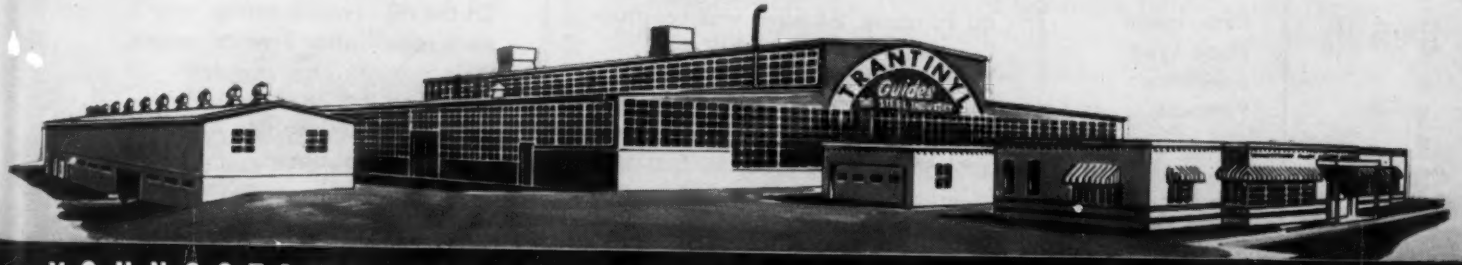
△ A new crane rail lubrication system that multiplies overhead crane wheel life approximately nine times and decreases rail wear by more than 20 per cent is being introduced to American industry by Research Appliance Co.

This patented crane rail lubricator, produced in Western Germany, is distributed exclusively by the company in both the U. S. and Canada. It is designed to sharply reduce wheel flange and crane rail wear, thus cutting repair costs and out-of-service time for cranes to a minimum.

SUPERIOR
CARBON
BRICK
FOR
Blast furnace linings
Blast furnace run-out troughs
Cupola linings
Steel pickling tanks
Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.
May we give you a quotation?
ELECTRODE GLC DIVISION
GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET, NEW YORK 17, N.Y. • OFFICES IN PRINCIPAL CITIES

TRANTINYL

guides the steel industry



YOUNGSTOWN ALLOY CASTING CORP., • YOUNGSTOWN, O.

ROLLING MILLS: bar, hoop, strip, shape mill guides, and rollers. SEAMLESS TUBE MILLS: guide shoes, rolling mill plugs and rolls, piercer points, etc. ELECTRIC WELD TUBE MILL: forming rolls, planishing rolls, tool holders, etc. • STRAIGHTENING MACHINE GUIDES • HEAT RESISTING CASTINGS

PROOF: B&W Refractories withstand CO and H_2 prepared atmospheres

ATMOSPHERE	APPLICATION	CONSTRUCTION	RESULTS
60% CO	Pusher Type Malleabilizing Furnace	Walls lined with B&W K-23 Insulating Firebrick backed with B&W K-20 IFB. Roof construction—9′-0″ wide sprung arch of B&W K-23 IFB.	No major rebuilding in 21 years.
40% CO	Radiant Tube Annealing Furnaces Malleable Iron Company	Bases lined with 7″ Kaocrete-A, backed with 6″ Kaolite-20. Base size—21′-9¾″ x 9′-9¼″. Temperature 1550 to 1600 F.	In service 11 years. Reducing atmosphere has no effect on the base. All portable annealing furnace bases in plant lined with B&W castables. *Maintenance costs reduced greatly.*
		Bell type covers lined with 9″ B&W K-23 IFB standard shapes in the arch, side and end walls. 13½″ K-23, with Kaowool, is used around the radiant tube openings. Cover is 22′-6″ x 10′-5½″ outside x 8′-4½″ to top of arch.	After approximately 6 years of service, lining showed no disintegration from reducing atmosphere.
65% CO	Radiant Tube Annealing Furnace	Base lined with 5½″ Kaocrete-A and 3½″ Kaolite-20 on top of 5½″ of block insulation. Base size 21′-9″ x 9′-9″. Temperature 1700 F.	Formerly heavy firebrick linings required rebuilding yearly. B&W castable construction has given more than 9 years' service. Customer standardized on B&W castables.
100% N_2 and 100% H_2	Elevator Type Annealing Furnaces Large Steel Co.	Walls lined with 9″ B&W K-23 IFB plus 3″ K-20 IFB. Furnace size 6′-0″ x 16′-0″ x 4′-0″. Temperatures in excess of 2100 F.	B&W refractories show no sign of deterioration in six furnaces of this type in 3 years' operation. Barring mechanical damage, refractories should give long additional service.
100% H_2	Rectangular Hood Type Annealing Furnaces	60 Furnaces, 24 have wall construction consisting of 18″ B&W K-26 IFB plus 2½″ K-1620 IFB. 36 units use wall of 9″ B&W K-26 IFB plus 5″ K-1620 IFB. Furnace size—12′-0″ x 8′-6″. Temperature 2150 F.	Of the 60 covers in service only 2 were rebuilt after 2 years' service. Plant masonry superintendent reports no shrinkage; estimates 15 years' additional life if not for mechanical abuse.

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Because of its adjustable construction, the DeLimon lubricator can be used on any size of rail or crane. It applies a thin film of lubricant—usually 3 to 4 grams per hour of long travel movement—automatically, without ever applying a drop to the top surface of the rails. The amount of lubricant used is so small that the rail is not even moist.

In service throughout Europe, the new system has increased the service life of crane wheels without overhaul from about four months to approximately three years.

The system is offered in single-rail, double-rail and combined crane and crane rail models.

In the single-rail system, one lubrication pump—usually mounted in the middle of the long travel—feeds the lubricant to two pendulum-mounted rail applicators mounted on the end carriage of the crane. The circular rollers forming the base of these penduli are pressed against the rail flanks by their own weight assisted by a tension spring. Lubricant passes through equidistant holes in the roller rims, which are surfaced with stiff felt.

The double crane rail system operates on the same principle except that two lubrication pumps are used, one mounted on each end of the crane, each feeding its own applicator. This system reduces material and installation costs in such installations.

The combined crane and crane rail lubrication system is available both as a single and as a double system, the lubricator having the additional function of feeding various bearings—for example, wheel bearings, thus giving complete lubrication protection to the long travel of the crane.

All systems can be supplied motorized, with motors in series with the long travel motor.

Book Reviews

"The Manufacture of Iron and Steel," Volume Three by R. Bashforth, has been recently published by Messrs. Chapman & Hall, 37 Essex St., London, W.C. 2, England. The book contains 246 pages, 5½ x 9 in., is cloth bound, and sells for 35s net. This book contains data on steelworks fuels, furnaces, refractories and instruments covering open hearth and liquid fuels, producer gas, open hearth plant and equipment as well as furnace, steelworks instruments and refractories, and policy and control of refractories. Also included are numerous conversion tables and arch formulae. Numerous line drawings, cross sections, tables, and photographs explain and illustrate the text.

"Mercury Barometers and Manometers," by W. G. Brombacher, D. P. Johnson, and J. L. Cross, has been recently published by the U. S. Department of Commerce, National Bureau of Standards (National Bureau of Standards Monograph 8.) The book contains 59 pages, 8 x 10 in., is bound in heavy paper, and is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., at 40¢. (Foreign remittances must be in U. S. exchange and include an additional 10¢ to cover mailing costs.) This

The revolutionary Bliss Pulsation Burner

produces temperatures never before achieved with oil or natural gas.Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

To learn how the Bliss Burner can increase the heat output in your plant while it's saving you money in fuel and furnace maintenance, write today for our Bulletin No. 60. It's yours for the asking.

BLISS
SINCE 1857

E. W. BLISS COMPANY
Canton, Ohio
BLISS is more than a name—it's a guarantee

YOU CAN USE A LARGER SHAFT WHEN YOUR "SPECS" READ HYATT

Need a larger shaft without disturbing envelope dimensions? Take advantage of a Hyatt option by omitting the inner race. You can add the thickness of the Hyatt inner race to the shaft and let the rollers operate directly on shaft. Just be sure that the shaft is suitably hardened and ground. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ***HY-ROLL BEARINGS***

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM GENERAL MOTORS RELIABILITY

monograph describes briefly the various designs of mercury barometers and manometers with a more extended discussion of the various design elements which may affect the achievable accuracy. Sources of error in measuring pressures are described in considerable detail, particularly for portable instruments, including scale, temperature, gravity, capillarity, vacuum errors, and return gas column. Methods of minimizing these errors and of making the corrections, including extensive tables, are presented. Standard conditions are defined and the pertinent properties of mercury given. The paper contains 65 literature references, it correlates scattered information and some unpublished data. It contains a short discussion of procedures used at the National Bureau of Standards for calibrating these instruments, along with instructions for submitting instruments to the Bureau for calibration.

"Properties of Elemental and Compound Semiconductors," Volume 5 of the Metallurgical Society Conferences series, edited by Harry C. Gatos, has been published recently by Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, New York. This book contains 340 pages, 6 x 9 in., is cloth bound, and sells for $8.50. This volume contains the proceedings of a technical conference, Boston, Mass., August 31–September 2, 1959, sponsored by the Semiconductors Committee of the Institute of Metals Division, The Metallurgical Society and Boston Section, American Institute of Mining, Metallurgical and Petroleum Engineers.

"Flat Rolled Products II: Semi-Finished and Finished," Volume 6, of the Metallurgical Society Conferences Series, edited by E. W. Earhart and R. D. Hindson, has been published recently by Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. This book contains 150 pages, 6 x 9 in., is cloth bound, and sells for $4.00. This volume contains the proceedings of the second technical conference, Chicago, Ill., January 20, 1960, sponsored by the Iron and Steel Div., The Metallurgical Society and Chicago Section, American Institute of Mining, Metallurgical and Petroleum Engineers. The book contains seven papers presented at this conference: Hot Machine Scarfing of Semi-Finished Carbon Steels by L. J. Trilli; Selection of Ingot and Slab Sizes for the Modern Strip Mill by W. W. Brown; Observations on the Scale Structures of Mild Steel Strip by S. Garber; Temper Rolling and Its Effect on Stretcher Strain Sensitivity" by E. J. Paliwoda and I. I. Bessen; Unitized Automobiles by C. W. Cenzer; Processing and Properties of Magnetic Materials by R. H. Trapp; and Processing and Properties of Magnetic Materials by P. H. Estes. The discussions following the papers presentation are also included. The papers are illustrated throughout with tables, charts, graphs, photographs.

"Transactions of the Vacuum Metallurgy Conference, 1959," edited by Rointan F. Bunshah, has been recently published by the Associated College Presses, 32 Washington Place, New York 3, N. Y. The book contains 212 pages, 8½ x 11 in., is bound in heavy pa-

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone*. Ask our engineers to help you solve your specific problems.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

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LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

AMERICAN Brake Shoe COMPANY
AMERICAN BRAKEBLOK DIVISION
P. O. BOX 21, BIRMINGHAM, MICHIGAN

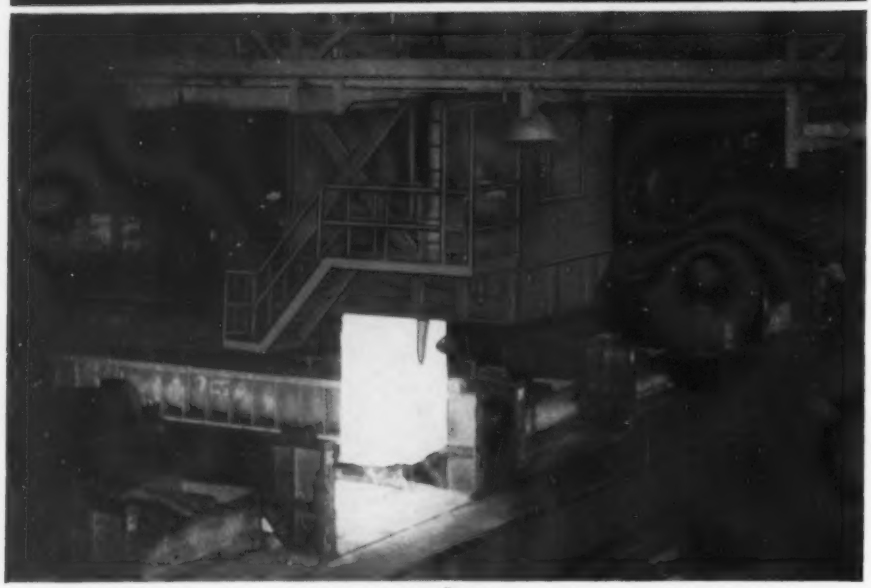
per, and sells for $7.50. This is a compilation of the papers presented during the Conference on Vacuum Metallurgy, June 1–3, 1959, sponsored by the Department of Metallurgical Engineering in cooperation with the Office of Special Services to Business and Industry, New York University, New York, N. Y. There are 20 papers included covering new research and advanced engineering information in vacuum metallurgy, presented by American and European scientist and engineers. These papers are on the general subjects of vacuum arc melting and casting, vacuum investment casting, vacuum induction melting, vacuum degassing, electron-beam techniques in vacuum metallurgy, and applications of vacuum metallurgy.

"Semiconductor Abstracts," Volume V, 1957, edited by C. S. Peet, has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. This book contains 449 pages, 8½ x 11 in., is cloth bound, and sells for $12.00. This volume contains abstracts of literature on semiconducting and luminescent materials and their applications compiled by Battelle Memorial Institute, sponsored by the Electrochemical Society, Inc. Organization of the abstracts is based on materials, and although most information can be located from the table of contents, a cross-referenced subject index and author index are provided. There are 1705 abstracts contained in the volume covering both elemental semiconductors and compound semiconductors, theory, and general applications.

"NEMA Standards Publication High-Voltage Fuses," SG2-1960, April, 1960, has been published recently by the National Electrical Manufacturers Assn., 155 E. 44th St., New York 17, N. Y. The book contains approximately 53 pages, 8½ x 11 in., is covered with heavy paper and sells for $3.00 a copy, available from NEMA. The standard covers distribution cutouts and distribution oil cutouts and their fuse links, distribution enclosed single-pole air switches, power fuses and current-limiting resistors. Information is given for: (1) ratings—continuous and short-time current, voltage, frequency, interrupting and load break; (2) tests—temperature rise, dielectric, interrupting, short-time current, load break, radio influence voltage, and time current curves. (3) application—selection of voltage and current ratings, usual service conditions, and spacings and clearances; and (4) manufacturing—nameplate marking, dimensions, mounting bracket, color coding, interchangeability of fuse links.

"X-ray Absorption and Emission in Analytical Chemistry," by H. A. Liebhafsky, H. G. Pfeiffer, E. H. Winslow, and P. D. Zemany, has been published recently by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. This book describes the history and underlying theory, the reliability of x-ray emission methods, a variety of applications, and all the necessary equipment and techniques to provide an understanding and use of modern methods of x-ray spectrochemical analysis, employing x-ray absorption or x-ray emission.

Although exposed to high ambient temperatures, this cab is easily kept at 80°-85 F. It means safer and better working conditions and improved production.



Hot enough to cook a crane operator

BUT IT DOESN'T HAPPEN HERE!

The man inside this crane cab is fresh and efficient because his cab is Lintern Air Conditioned. In spite of that hot ingot, the operator enjoys a comfortable temperature the year around. He's free of fumes, gases, dirt and the fatigue that excessive heat brings on.

Thanks to **LINTERN AIR CONDITIONING**

hundreds of plants have improved efficiency. Right now Lintern is busy modernizing the crane cabs and pulpits of dozens of plants. This means they'll enjoy more output, less labor turnover, a greater return on their capital investment.

Maybe you should do this, too. It costs nothing to find out.

Write for Bulletin AC-573.

Larco, inc.
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS
ROUTE 20 EAST • PAINESVILLE, OHIO

MORE THAN 5,000,000 TONS OF STEEL WITHOUT A BEARING FAILURE

The Torrington Company, Bantam Bearings Division, South Bend, Indiana, is especially noted for the high quality of its rolling mill bearings. Usage of modified AISI 3310 USS CARILLOY Steel in races enables Torrington to manufacture quality bearings with a foot-pound energy absorption rate of a magnitude impossible to obtain with any other conventional alloy steel. Translated into performance, rolling mills equipped with these bearings have produced more than 5,000,000 tons of steel without a bearing failure!

Before using the modified USS Alloy grade, Torrington tried several different types of steel which gave considerably lower tonnages before failure occurred. Then with the application of the 4% nickel alloy (Modified 3310) they first succeeded in obtaining progressively higher tonnages to the 5,000,000-plus tons of rolled steel production enjoyed today.

In addition, the Torrington Company uses the 52100 series of USS CARILLOY Steels. The types of 52100 steels used in through-hardening anti-friction bearings consist of grades similar to AISI 50100, 51100, and 52100. These steels have certain special characteristics such as wear resistance and compressive properties essential in bearings, which are obtained by adding varying amounts of chromium to high carbon steels.

The chromium, manganese, silicon are varied according to the cross section involved in the finished part and its expected response to heat treatment, or the microstructure needed to impart wear and other special properties. USS CARILLOY Steels in this class have long been noted for their superior quality, cleanliness and wear resistance.

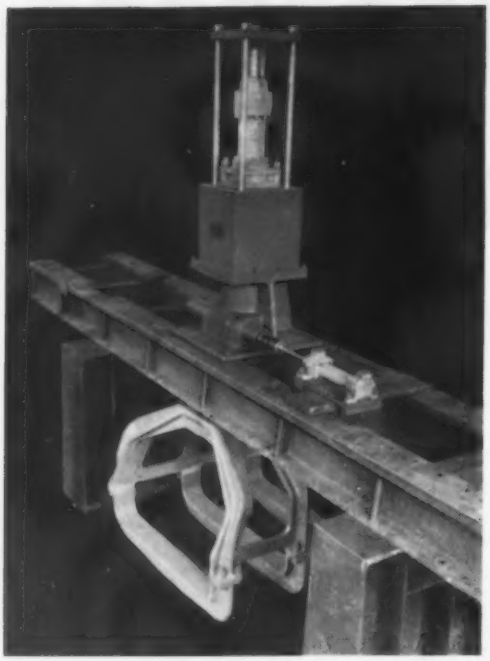
Special alloy steels such as those used by Torrington can be developed for other special needs. In addition, all standard alloy steel grades in a complete range of USS bar and semi-finished sizes are available. For more information, write United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and CARILLOY are registered trademarks

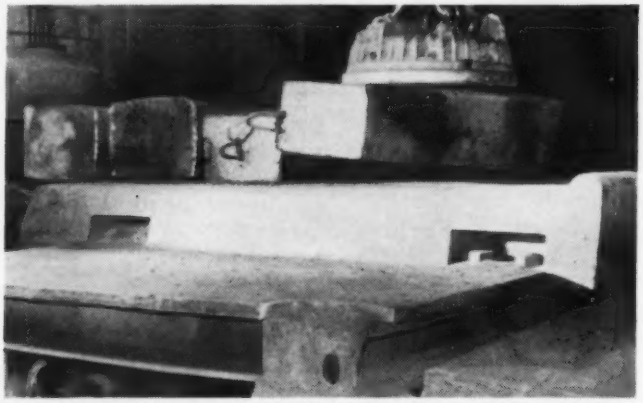
This mark tells you a product is made of modern, dependable Steel.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Ala.
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel

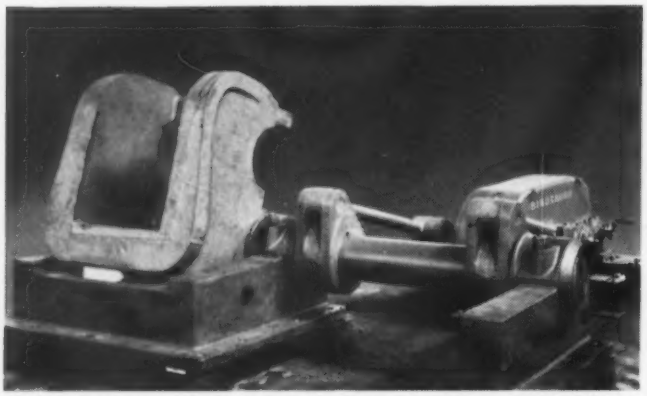
Inspector checking a Torrington 4-row tapered roller bearing used in metal rolling mills. A special 4% nickel alloy was used for greater wearing qualities.



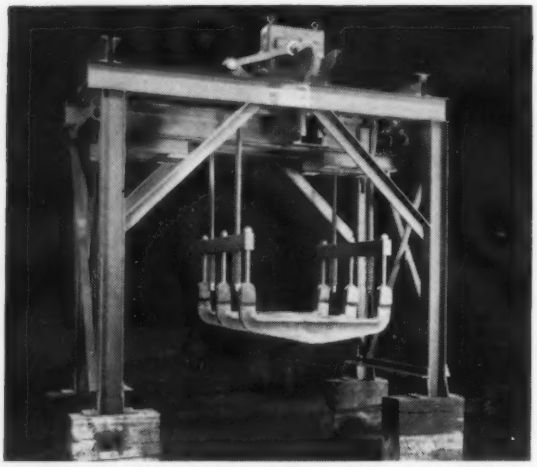
Ingot Turn-about arranged for mounting over mill approach table.



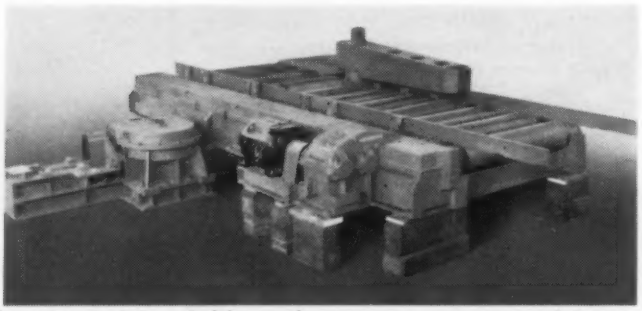
Ingot feeder bed and chain conveyor, receives ingots from crane and feeds up slope to ingot furnace charging table and pushers.



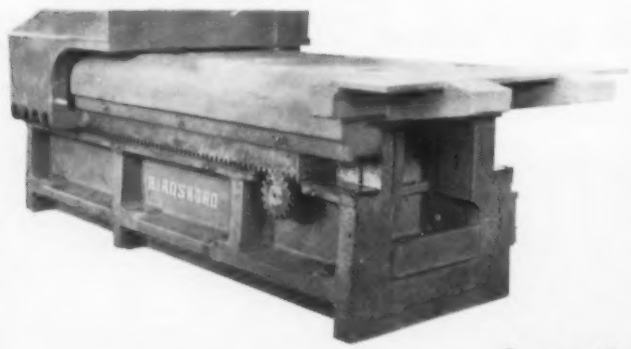
Stationary ingot tilting pot for receiving ingots from crane and laying them on mill approach table.



Ingot weighing scale arranged for mounting over mill approach table.



Ingot receiving table and sweep arm arranged to receive ingots from tilting pot buggy and to place them either end first on mill approach table.



Ingot pusher to mill approach table arranged to receive ingots from pit crane.

Ingot Weighing and Handling Equipment by

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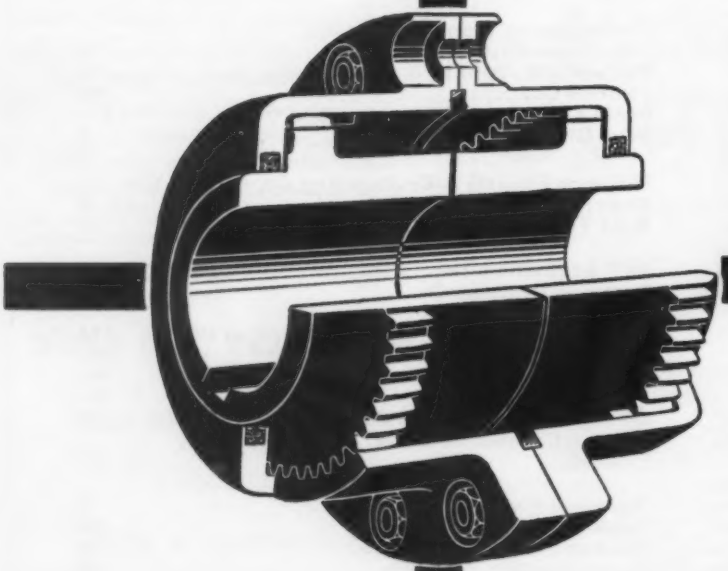

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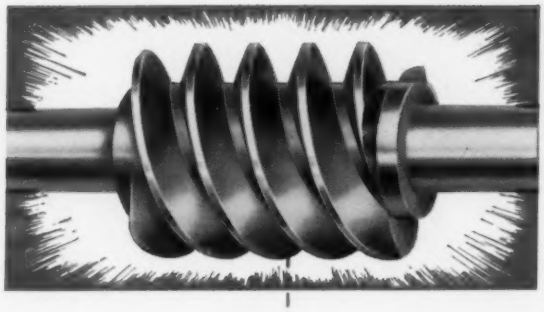

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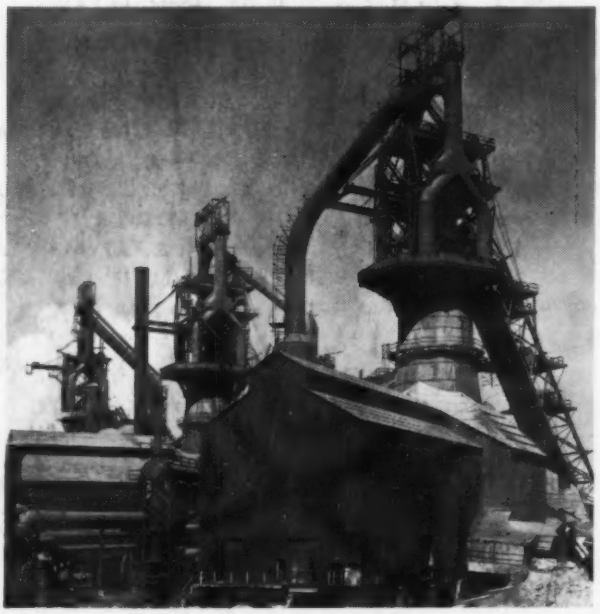

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